NbaProject

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8/12/2020

Introduction

In this project we want to classify the position of the basketball NBA players with his stats(points, assistances, ofensive rebounds, defensive rebounds, steals, blocks,free throws,Turnovers Per Game, field Goal Percentage,free throws per game(FT) and free throw Percentage(FT.)). In order to improve the performance of the model, we simplify the positions in three groups; guards, forwards and centers.

```
## -- Attaching packages --------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.2     v purrr   0.3.4
## v tibble  3.0.3     v dplyr   1.0.2
## v tidyr   1.1.2     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0

## Warning: package 'stringr' was built under R version 4.0.3

## -- Conflicts ------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()

##
## Attaching package: 'data.table'

## The following objects are masked from 'package:dplyr':
##
##     between, first, last

## The following object is masked from 'package:purrr':
##
##     transpose

##
## Attaching package: 'MASS'

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

## Warning: package 'VGAM' was built under R version 4.0.3
```

```
## Loading required package: stats4

## Loading required package: splines

##
## Attaching package: 'VGAM'

## The following object is masked from 'package:tidyr':
##
##     fill

## Warning: package 'klaR' was built under R version 4.0.3

## Warning: package 'caret' was built under R version 4.0.3

## Loading required package: lattice

##
## Attaching package: 'caret'

## The following object is masked from 'package:VGAM':
##
##     predictors

## The following object is masked from 'package:purrr':
##
##     lift

## Warning in read.table(file = file, header = header, sep = sep, quote = quote, :
## not all columns named in 'colClasses' exist
```

Preprocess

First of all, we will check that we have enough data in each group. In order to avoid outlayers, we remove the players who plays less than five minutes per game and players who doesnt have full data.

```
## [1] "Number of Centers"

## [1] 116

## [1] "Number of fowards"

## [1] 219

## [1] "Number of Guards"

## [1] 205
```

Effectively, there is the same order of number of data per group .Then, I compute the covariance matrix of each group

```
## [1] "Covariance of the centers"
```

```
##             PTS         AST         ORB          DRB          STL          BLK
## PTS 25.89537031  3.52569715  2.94353823  9.517673163  1.114926537  1.574998501
## AST  3.52569715  0.98789430  0.31766342  1.317237631  0.205635682  0.135410045
## ORB  2.94353823  0.31766342  0.84564543  1.689918291  0.154166417  0.260771364
## DRB  9.51767316  1.31723763  1.68991829  5.219000750  0.527986507  0.788327586
## STL  1.11492654  0.20563568  0.15416642  0.527986507  0.128764618  0.102712144
## BLK  1.57499850  0.13541004  0.26077136  0.788327586  0.102712144  0.294850825
## FT   4.57330435  0.61584783  0.54950000  1.643239130  0.184913043  0.256326087
## FG. -0.03281694 -0.01493954  0.02681642  0.008547811 -0.004257991  0.004587361
## FT.  0.09502036  0.01344507 -0.02336165 -0.004256882  0.002601259 -0.006426807
## TOV  2.83404798  0.46568291  0.40194678  1.234582459  0.170646177  0.169186657
##               FT          FG.          FT.          TOV
## PTS  4.573304348 -0.032816942  0.095020360  2.834047976
## AST  0.615847826 -0.014939535  0.013445067  0.465682909
## ORB  0.549500000  0.026816417 -0.023361649  0.401946777
## DRB  1.643239130  0.008547811 -0.004256882  1.234582459
## STL  0.184913043 -0.004257991  0.002601259  0.170646177
## BLK  0.256326087  0.004587361 -0.006426807  0.169186657
## FT   1.079630435 -0.002039565  0.020980870  0.535891304
## FG. -0.002039565  0.008414748 -0.005354575 -0.004422084
## FT.  0.020980870 -0.005354575  0.014082921  0.001749985
## TOV  0.535891304 -0.004422084  0.001749985  0.461135682
```

```
## [1] "Covariance of the fowards"
```

```
##            PTS        AST           ORB        DRB         STL         BLK
## PTS 33.7951452 4.79140819  1.4585597587 7.16701332 1.238476813 0.825441749
## AST  4.7914082 1.29939843  0.2293071090 1.31453521 0.236951531 0.120604499
## ORB  1.4585598 0.22930711  0.3217221733 0.58966047 0.053604583 0.087873570
## DRB  7.1670133 1.31453521  0.5896604667 2.75951405 0.326305978 0.268497549
## STL  1.2384768 0.23695153  0.0536045830 0.32630598 0.137255666 0.052051024
## BLK  0.8254417 0.12060450  0.0878735704 0.26849755 0.052051024 0.104132211
## FT   6.7500421 1.05804973  0.3062094173 1.41255603 0.246510829 0.168380043
## FG.  0.1454519 0.01867684  0.0166113003 0.03629829 0.004672048 0.005880420
## FT.  0.2514675 0.02718920 -0.0000710695 0.04509232 0.009002689 0.002375575
## TOV  3.1873652 0.60199405  0.1791923254 0.83906539 0.129168866 0.093164509
##             FT          FG.           FT.        TOV
## PTS 6.75004210 0.1454518726  0.2514674815 3.18736521
## AST 1.05804973 0.0186768422  0.0271892045 0.60199405
## ORB 0.30620942 0.0166113003 -0.0000710695 0.17919233
## DRB 1.41255603 0.0362982929  0.0450923212 0.83906539
## STL 0.24651083 0.0046720477  0.0090026895 0.12916887
## BLK 0.16838004 0.0058804198  0.0023755750 0.09316451
## FT  1.70154623 0.0254849964  0.0481261217 0.67403146
## FG. 0.02548500 0.0043701546  0.0005755507 0.01336336
## FT. 0.04812612 0.0005755507  0.0141449942 0.01485231
## TOV 0.67403146 0.0133633551  0.0148523124 0.42002304
```

```
## [1] "Covariance of the guards"
```

```
##            PTS         AST          ORB        DRB         STL            BLK
## PTS 44.4846375 10.47452248  0.947503348 6.42088307 1.415625299  0.3860033477
## AST 10.4745225  4.40093639  0.314500956 1.80799880 0.501523195  0.1022852702
## ORB  0.9475033  0.31450096  0.104635103 0.27516691 0.072871832  0.0263213773
## DRB  6.4208831  1.80799880  0.275166906 1.62967862 0.327268054  0.1012355332
## STL  1.4156253  0.50152319  0.072871832 0.32726805 0.159911526  0.0311561454
## BLK  0.3860033  0.10228527  0.026321377 0.10123553 0.031156145  0.0279684362
## FT   9.3977243  2.44725036  0.196042085 1.32476112 0.296285270  0.0900518890
## FG.  0.1108489  0.02603443  0.005526937 0.02126547 0.005987901  0.0018906624
## FT.  0.2216955  0.04391116 -0.003211683 0.01528867 0.000325550 -0.0008953109
## TOV  5.4291801  1.73383716  0.158099235 0.90900096 0.225065758  0.0571972740
##             FT          FG.           FT.        TOV
## PTS 9.39772429 0.1108489479  0.2216955380 5.42918006
## AST 2.44725036 0.0260344333  0.0439111621 1.73383716
## ORB 0.19604209 0.0055269369 -0.0032116834 0.15809923
## DRB 1.32476112 0.0212654711  0.0152886729 0.90900096
## STL 0.29628527 0.0059879005  0.0003255500 0.22506576
## BLK 0.09005189 0.0018906624 -0.0008953109 0.05719727
## FT  2.47266284 0.0197836920  0.0534275060 1.24848207
## FG. 0.01978369 0.0024472764  0.0005431131 0.01135088
## FT. 0.05342751 0.0005431131  0.0129805723 0.01931797
## TOV 1.24848207 0.0113508847  0.0193179723 0.88357341
```

We can see that they are difference but the values have the same order.Even so, we will proceed later to standardize it. Before, to archive normality, we make transformation of the variables. After that, we recompute the covariance matrix

```
## [1] "Covariance of the centers"
```

```
##             PTS         AST        ORB         DRB        STL          BLK
## PTS  0.79417797  0.55915041  0.4043203  0.70533205  0.5994261  0.28469067
## AST  0.55915041  0.71612874  0.2783294  0.54169944  0.5069762  0.14945842
## ORB  0.40432027  0.27832939  0.5924636  0.55666322  0.3317443  0.20645570
## DRB  0.70533205  0.54169944  0.5566632  0.91568020  0.6086413  0.32357256
## STL  0.59942612  0.50697624  0.3317443  0.60864127  1.0519905  0.28119828
## BLK  0.28469067  0.14945842  0.2064557  0.32357256  0.2811983  0.29485082
## FT   0.62367447  0.44512431  0.3815816  0.55399590  0.4440059  0.20500168
## FG. -0.01258919 -0.11148199  0.2755258  0.07545171 -0.1196429  0.04257949
## FT.  0.14751479  0.06524289 -0.1926409 -0.02526658  0.1138799 -0.05082599
## TOV  0.58640428  0.50079929  0.4061770  0.62424589  0.4850665  0.21992627
##             FT         FG.         FT.         TOV
## PTS 0.62367447 -0.01258919  0.14751479  0.58640428
## AST 0.44512431 -0.11148199  0.06524289  0.50079929
## ORB 0.38158157  0.27552584 -0.19264090  0.40617697
## DRB 0.55399590  0.07545171 -0.02526658  0.62424589
## STL 0.44400589 -0.11964293  0.11387994  0.48506646
## BLK 0.20500168  0.04257949 -0.05082599  0.21992627
## FT  0.67679499  0.06000208  0.16448592  0.52200476
## FG. 0.06000208  0.91913571 -0.46535513 -0.01916509
## FT. 0.16448592 -0.46535513  0.97058148  0.03635870
## TOV 0.52200476 -0.01916509  0.03635870  0.67110749
```

```
## [1] "Covariance of the centers"
```

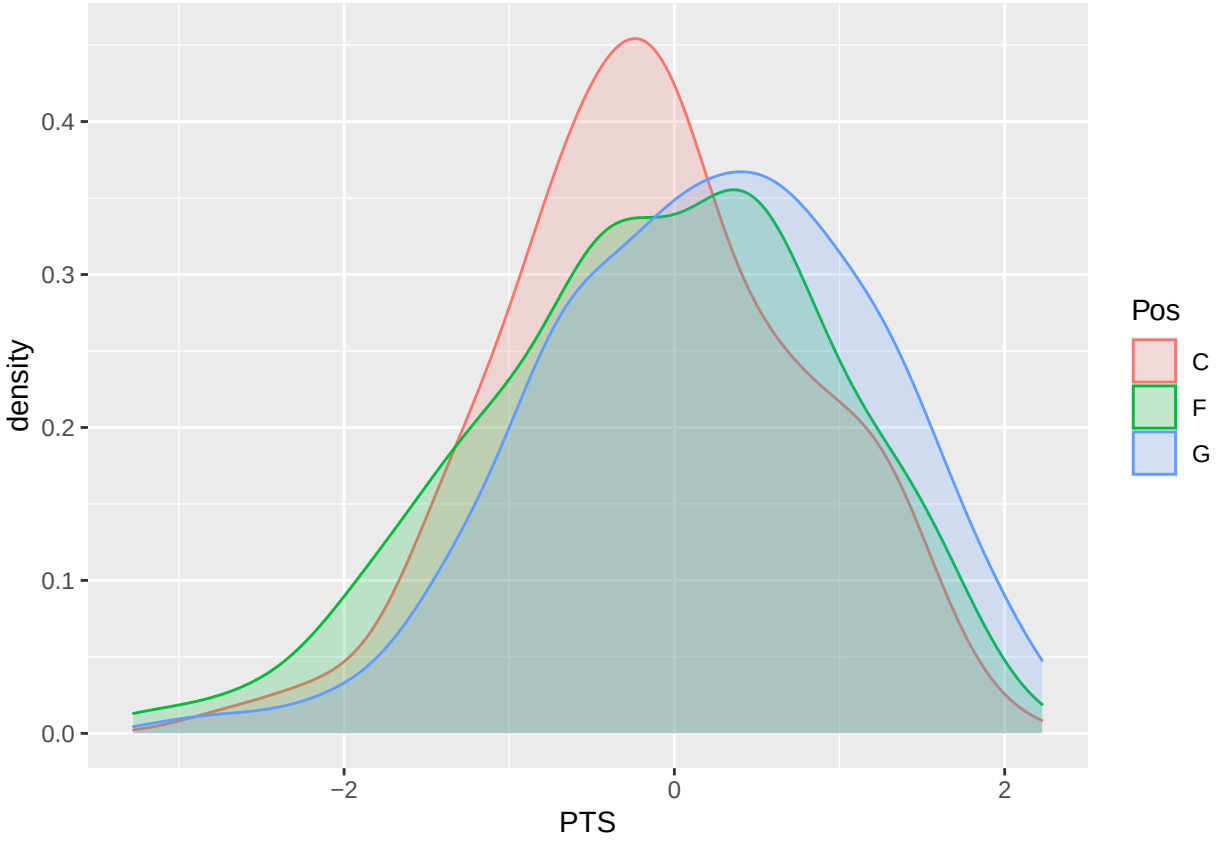
```
##           PTS        AST        ORB       DRB       STL        BLK        FT
## PTS 1.0993531 0.70707179 0.39051132 0.7426921 0.7054596 0.14091470 0.9333991
## AST 0.7070718 0.74888037 0.27605433 0.5892128 0.5640887 0.09856567 0.6129242
## ORB 0.3905113 0.27605433 0.65686092 0.4860057 0.2507990 0.11682747 0.3820625
## DRB 0.7426921 0.58921281 0.48600566 0.8730927 0.5060270 0.14252297 0.6408626
## STL 0.7054596 0.56408869 0.25079905 0.5060270 1.0614192 0.12090309 0.6162114
## BLK 0.1409147 0.09856567 0.11682747 0.1425230 0.1209031 0.10413221 0.1234833
## FT  0.9333991 0.61292423 0.38206247 0.6408626 0.6162114 0.12348328 1.0843651
## FG. 0.4236563 0.23760146 0.29685317 0.2798861 0.2177309 0.07900509 0.3503076
## FT. 0.5092272 0.23595553 0.07684454 0.3243164 0.2461758 0.02359937 0.5125402
## TOV 0.8141719 0.70038178 0.40177350 0.7212685 0.6320934 0.13598246 0.7870101
##            FG.        FT.       TOV
## PTS 0.42365630 0.50922724 0.8141719
## AST 0.23760146 0.23595553 0.7003818
## ORB 0.29685317 0.07684454 0.4017735
## DRB 0.27988609 0.32431638 0.7212685
## STL 0.21773088 0.24617581 0.6320934
## BLK 0.07900509 0.02359937 0.1359825
## FT  0.35030758 0.51254022 0.7870101
## FG. 0.82513853 0.10720968 0.2698685
## FT. 0.10720968 1.02939441 0.2899503
## TOV 0.26986855 0.28995025 1.0208962
```

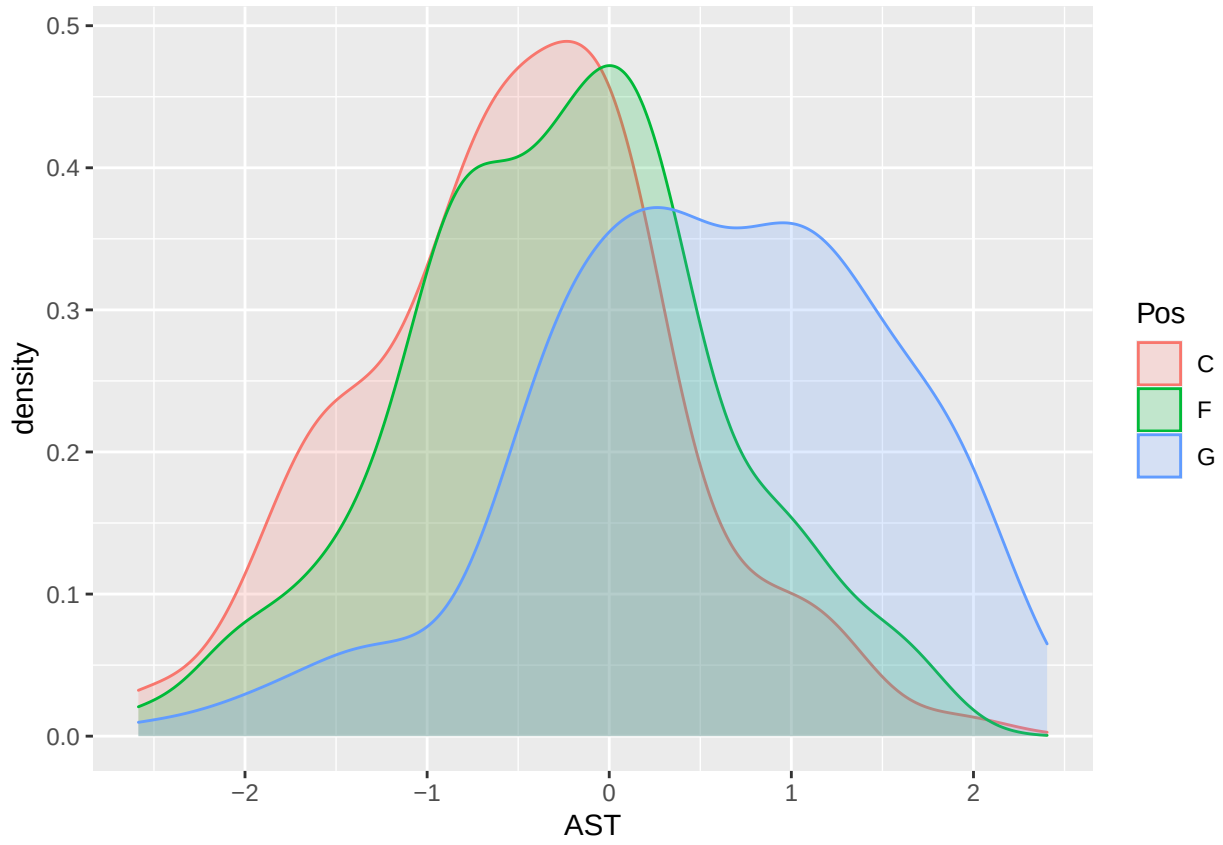
```
## [1] "Covariance of the centers"
```

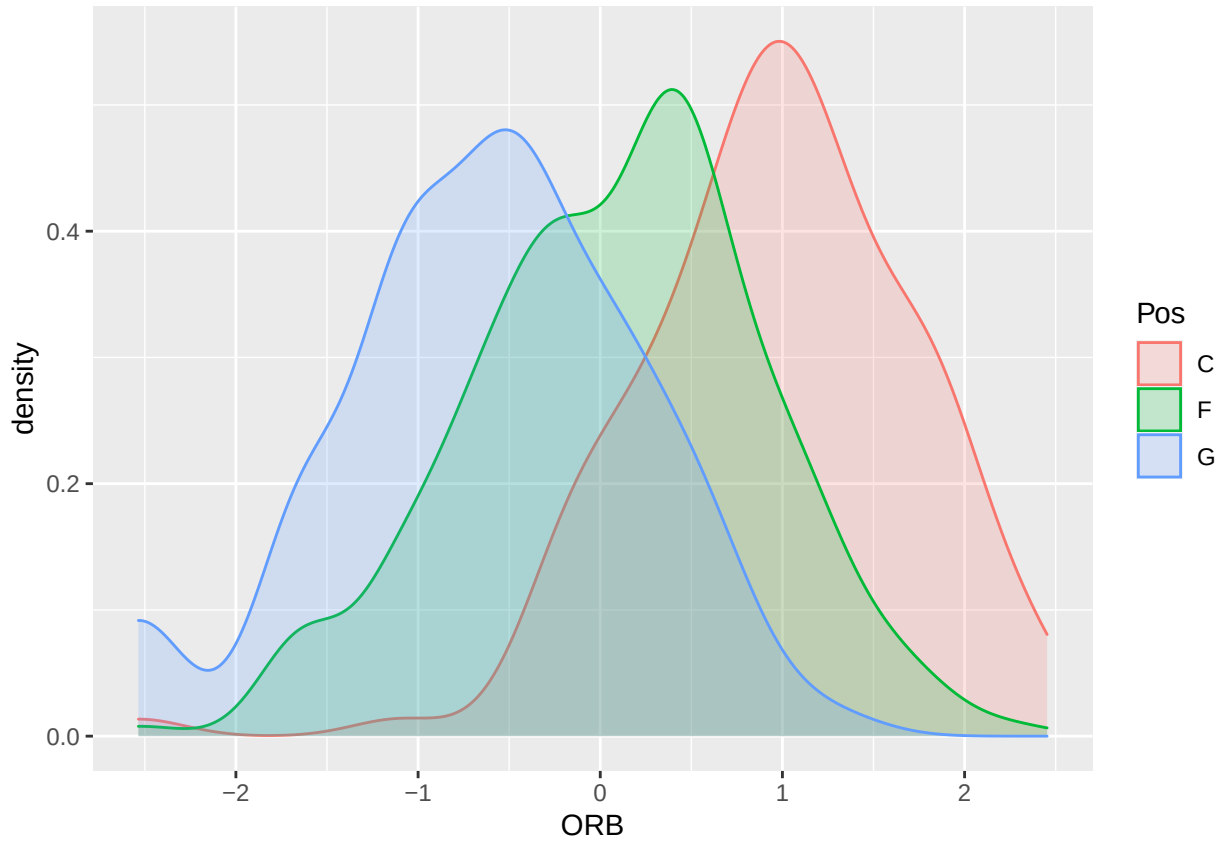
```
##            PTS        AST         ORB        DRB        STL           BLK
## PTS 0.95122342 0.70964382 0.396309168 0.75065593 0.51707753  0.056375262
## AST 0.70964382 0.92358751 0.368046922 0.62687728 0.52963686  0.046308148
## ORB 0.39630917 0.36804692 0.684881197 0.50577484 0.39850842  0.065946630
## DRB 0.75065593 0.62687728 0.505774844 0.90483056 0.56302830  0.073676406
## STL 0.51707753 0.52963686 0.398508422 0.56302830 0.78350488  0.064131588
## BLK 0.05637526 0.04630815 0.065946630 0.07367641 0.06413159  0.027968436
## FT  0.88088716 0.71392595 0.385272419 0.68350066 0.45888299  0.059919596
## FG. 0.29689618 0.15823616 0.208649967 0.26356818 0.18497231  0.027623842
## FT. 0.31137550 0.21053604 0.006732983 0.17666225 0.03565441 -0.004173223
## TOV 0.81837006 0.85279305 0.448355686 0.73975520 0.55984150  0.065086088
##            FT        FG.          FT.        TOV
## PTS 0.8808872 0.29689618  0.311375504 0.81837006
## AST 0.7139260 0.15823616  0.210536044 0.85279305
## ORB 0.3852724 0.20864997  0.006732983 0.44835569
## DRB 0.6835007 0.26356818  0.176662249 0.73975520
## STL 0.4588830 0.18497231  0.035654406 0.55984150
## BLK 0.0599196 0.02762384 -0.004173223 0.06508609
## FT  1.0666055 0.21973323  0.387802861 0.81889935
## FG. 0.2197332 0.49827060  0.105785920 0.18674047
## FT. 0.3878029 0.10578592  0.825752048 0.20570112
## TOV 0.8188994 0.18674047  0.205701115 1.03888339
```

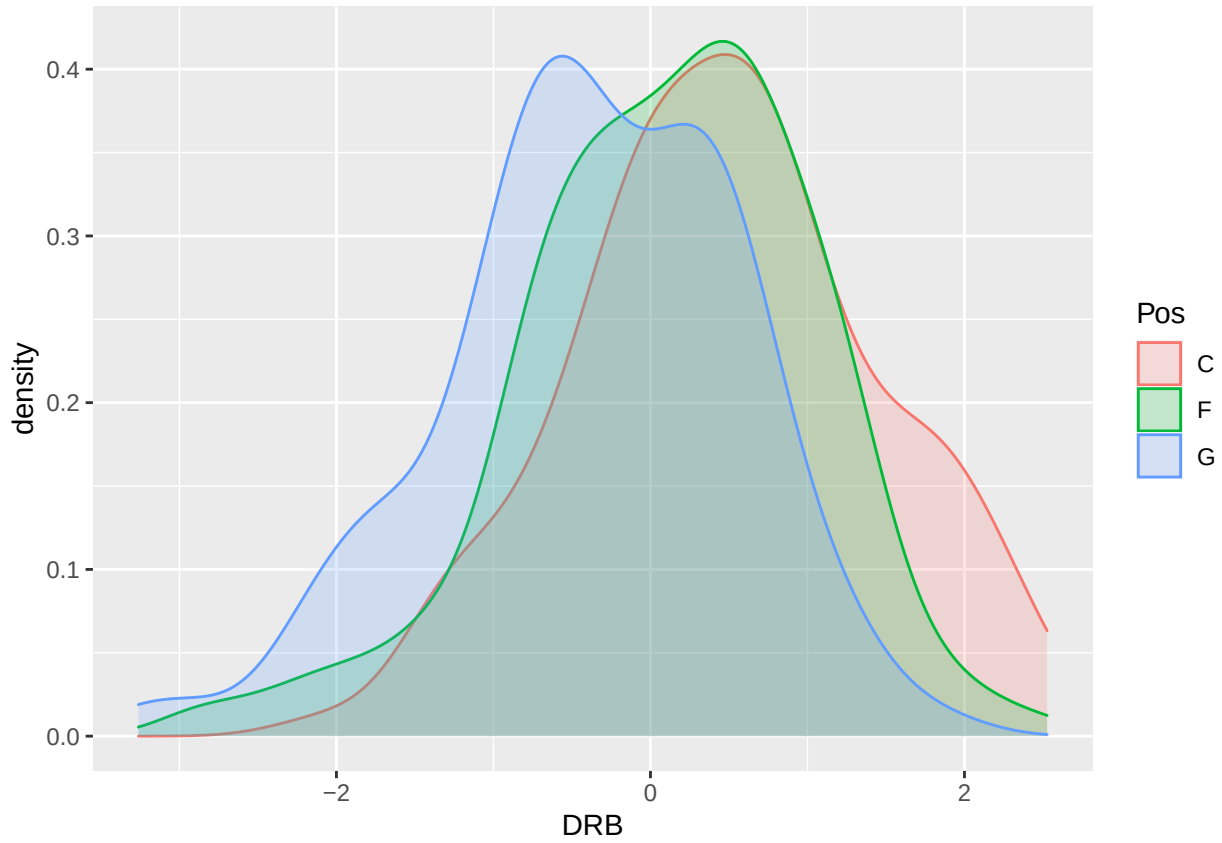
I plot the density function of all variables after transform in logarithm. We could see differences that we can reason a priori. From all positions you can score many points, make fouls or have good shooting percentages (although centers when shooting from closer, should have a slightly higher hit percentage). However, centers, being higher, will take average more rebounds than fowards and the latter more than guards. The same, to a lesser extent, happens with blocks. However, as guards create more game than fowards they tend to give

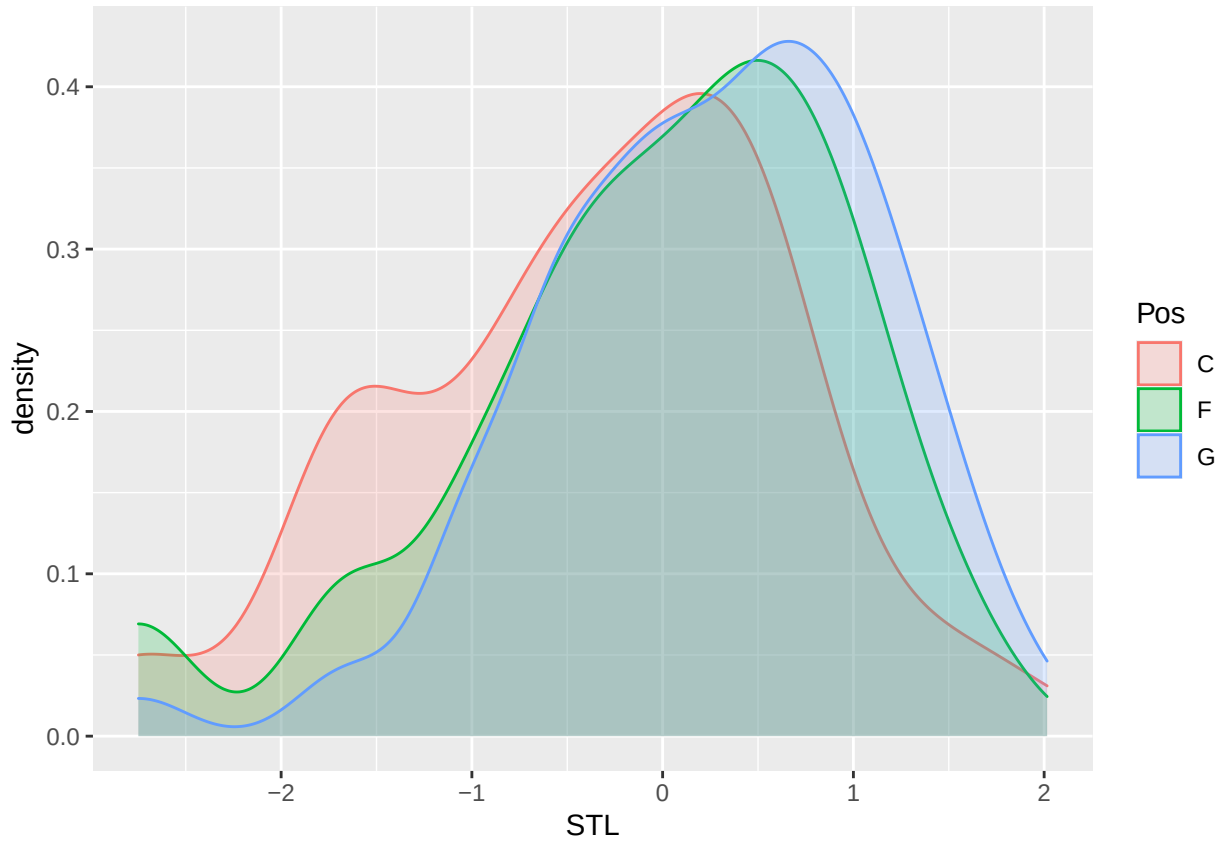
more assists than fowards and and these more than centers, something similar happens with steals,turnovers and free throw percentages.

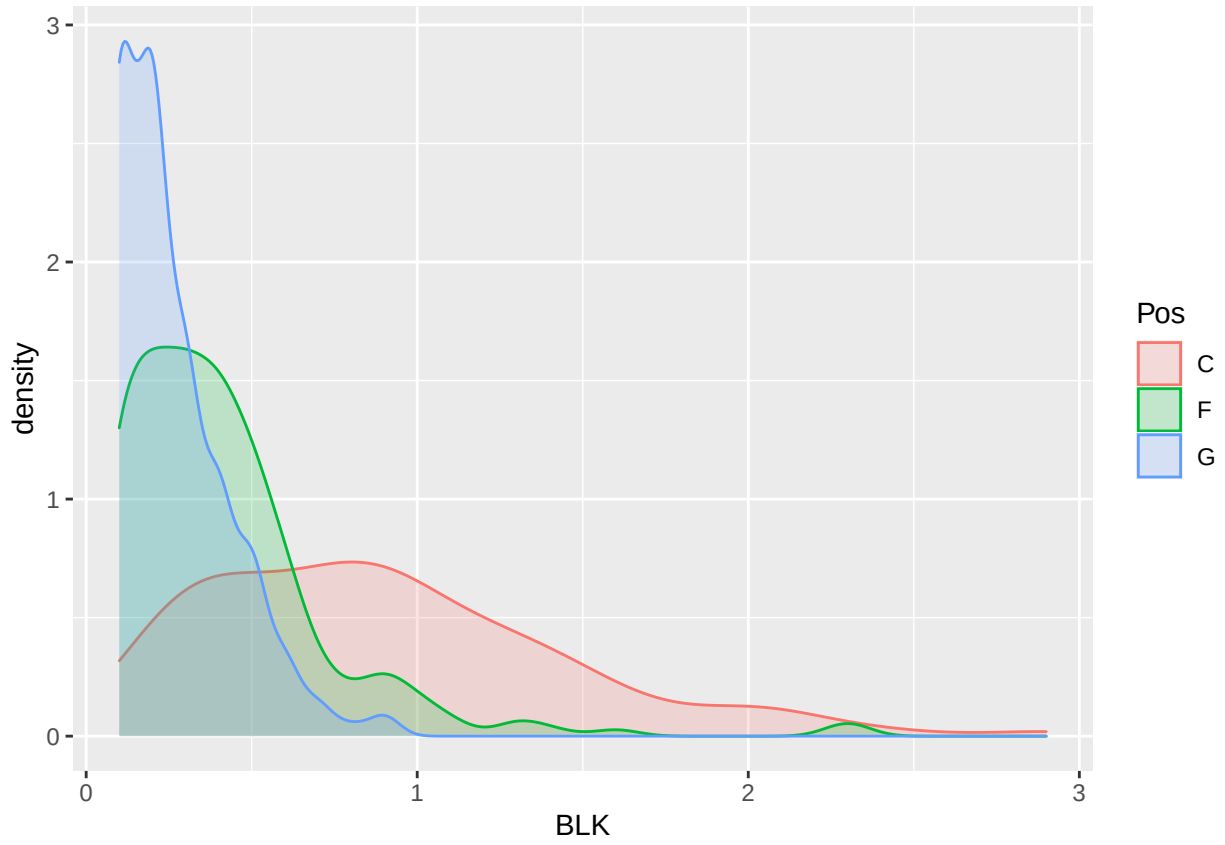


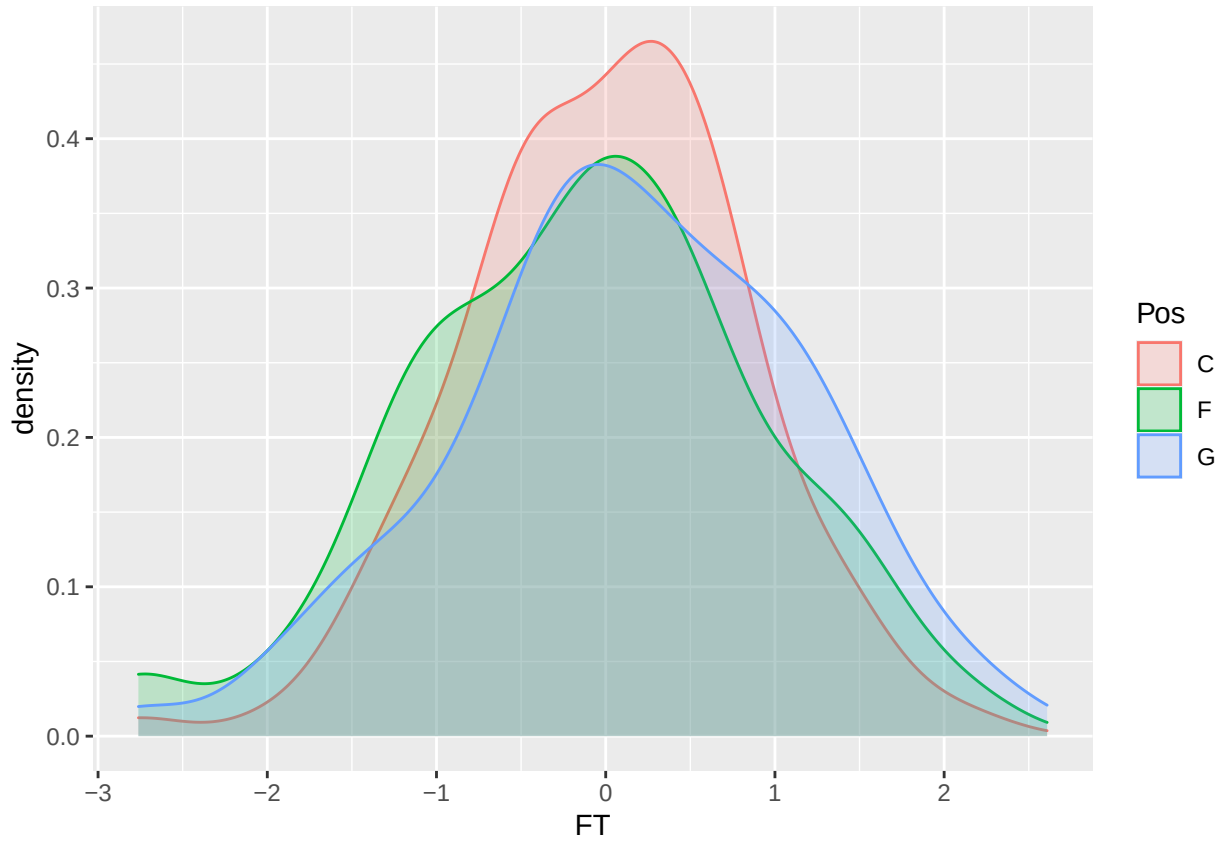

0.5
0.4
0.3
0.2
0.1
0.0
density
−2
−1
0
1
2
AST
Pos
C
F
G

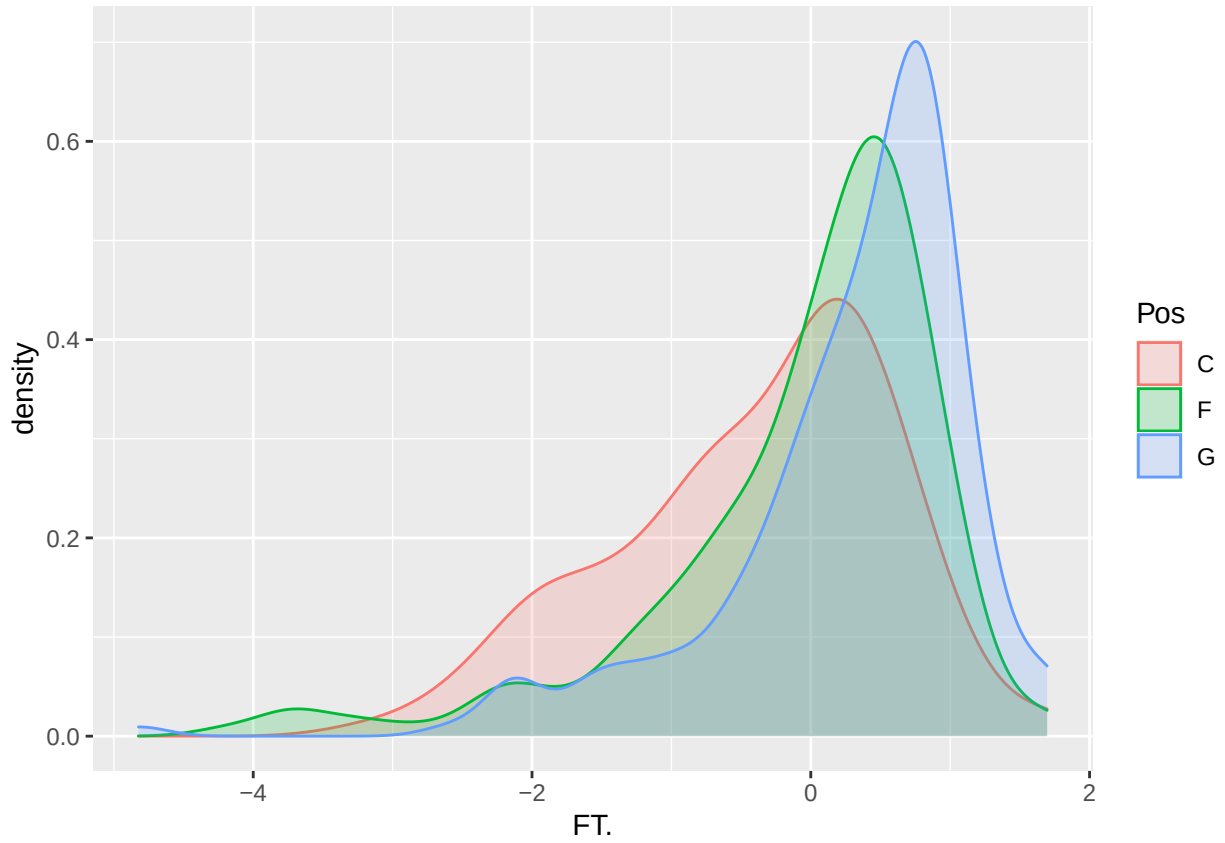

density
0.4
0.2
0.0
−2
−1
0
1
2
ORB
Pos
C
F
G

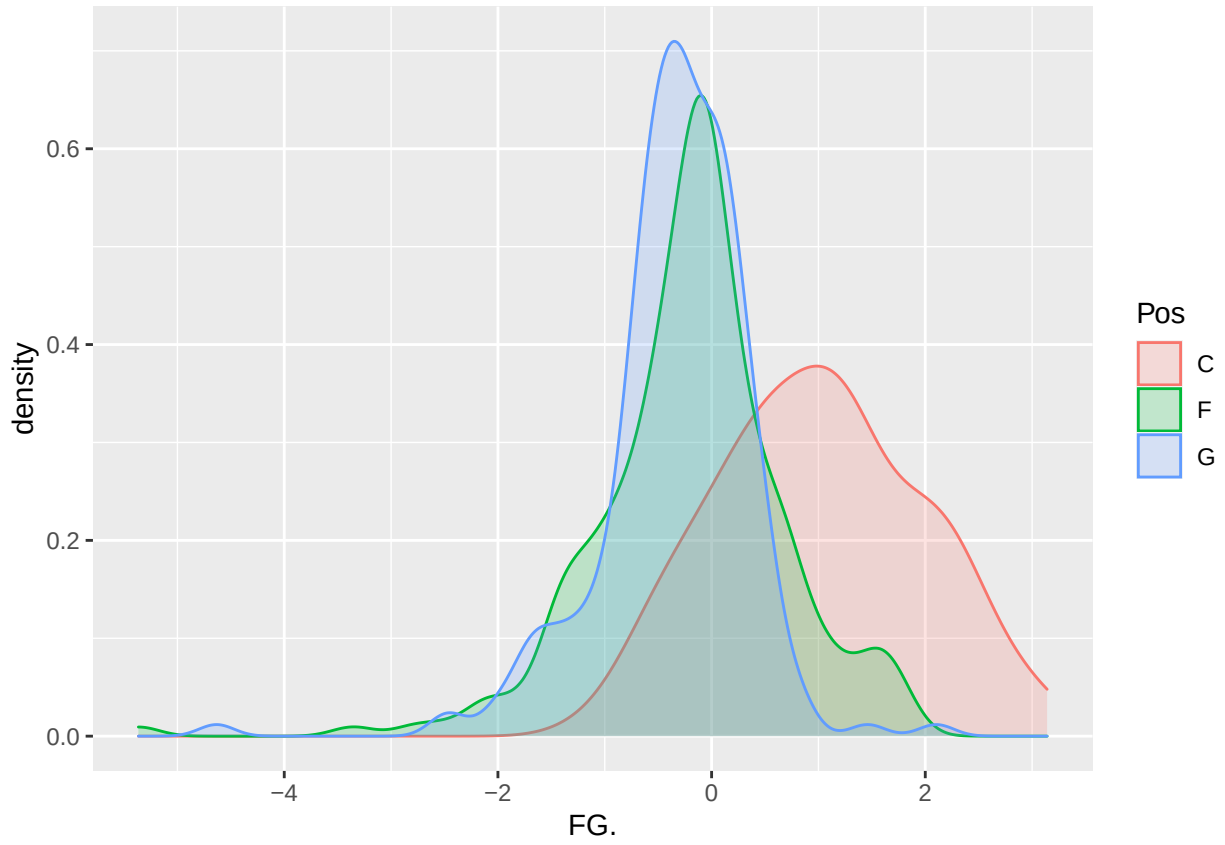

0.4
0.3
0.2
0.1
0.0
density
−2
0
2
DRB
Pos
C
F
G

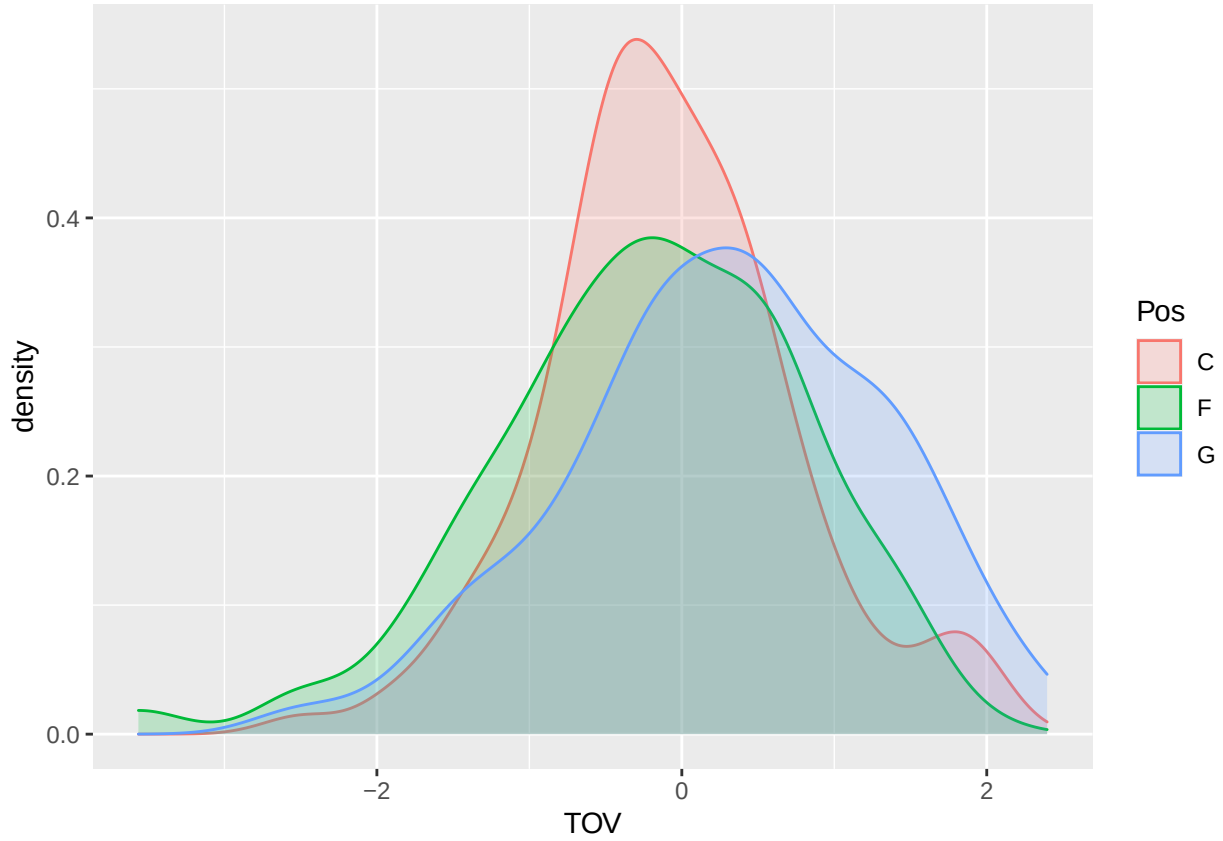

density
0.4
0.3
0.2
0.1
0.0
−2
−1
0
1
2
STL
Pos
C
F
G


density
3
2
1
0
0
1
2
3
BLK
Pos
C
F
G

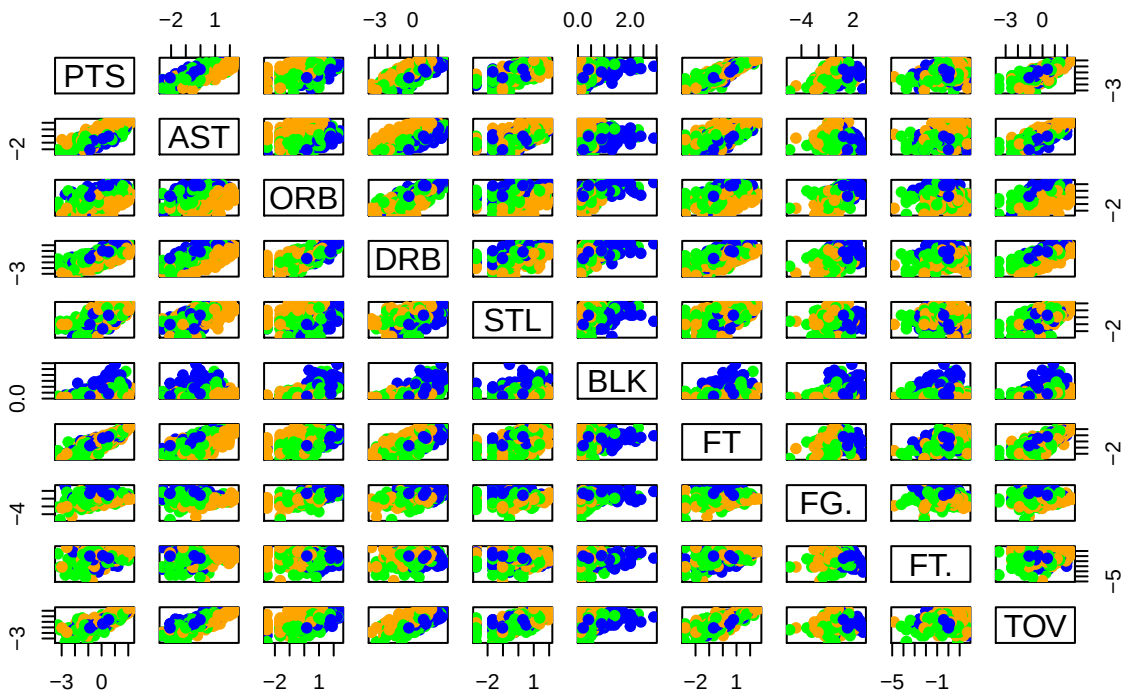

density
0.4
0.3
0.2
0.1
0.0
−3
−2
−1
0
1
2
FT
Pos
C
F
G


density
0.6
0.4
0.2
0.0
−4
−2
0
2
FT.
Pos
C
F
G


density
0.6
0.4
0.2
0.0
−4
−2
0
2
FG.
Pos
C
F
G



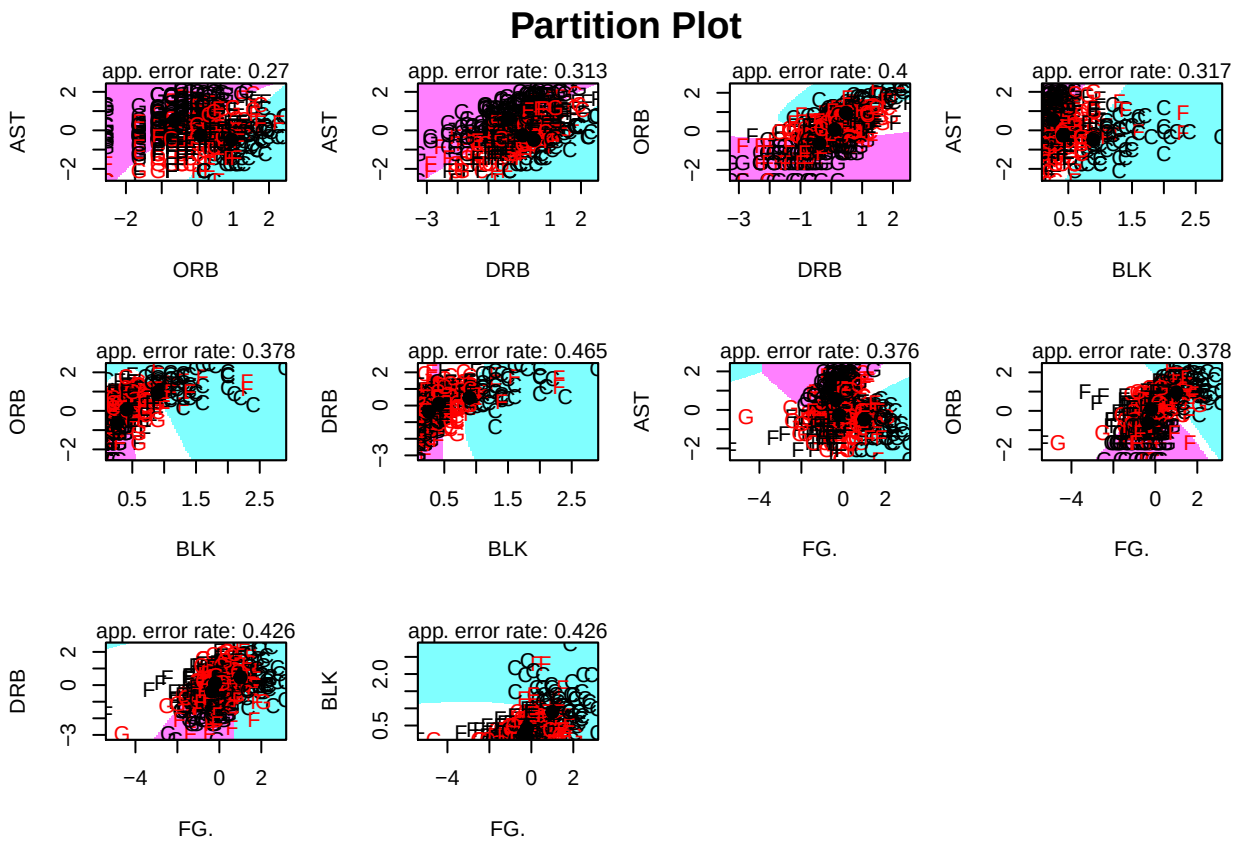
The hypothesis seems to be correct except with steals. Then, we proceed to make de scatterplot to see which variables will be more relevants in order to classify



We can see that the rebounds and assistances are the most relevant variables to classify

Finally we will use the staticals tools. I start with QDA. The partitions representation will be with the most important variables.

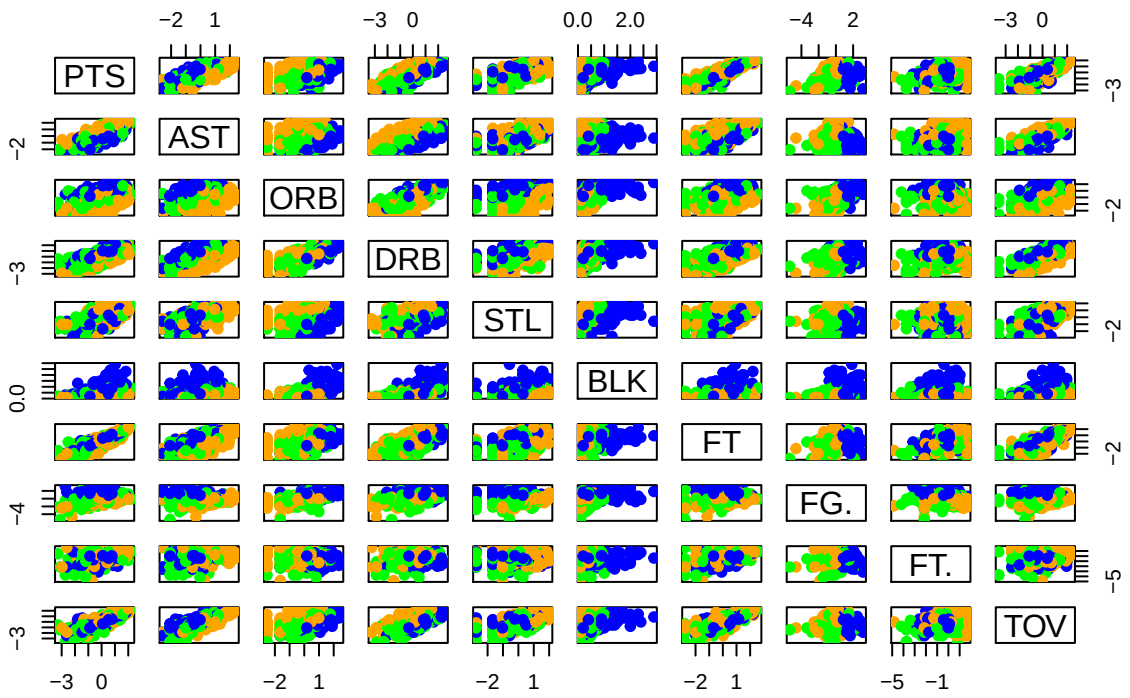
```
## Call:
## qda(Pos ~ ., data = my_data, prior = c(1, 1, 1)/3)
##
## Prior probabilities of groups:
##         C         F         G
## 0.3333333 0.3333333 0.3333333
##
## Group means:
##          PTS        AST         ORB        DRB         STL       BLK
## C -0.1373697 -0.4877953  0.95494088  0.4738070 -0.35065868 0.8956897
## F -0.1194755 -0.2591698  0.08156008  0.1081612 -0.04210344 0.4164384
## G  0.2053659  0.5528899 -0.62748683 -0.3836532  0.24340029 0.2614634
##              FT         FG.          FT.         TOV
## C  0.004483949  1.0057331 -0.39450965 -0.0792695
## F -0.127186069 -0.2033194 -0.05160357 -0.2197642
## G  0.133334688 -0.3518932  0.27836244  0.2796274
```



The ofensive rebounds and the blocks are the best variables to classify the centers. It is logical because the center are the highest players and the can catch more rebounds and the have more facilities to block.The guards, who usually make more assistances have the higher cofficient.Now we will predict with the same data

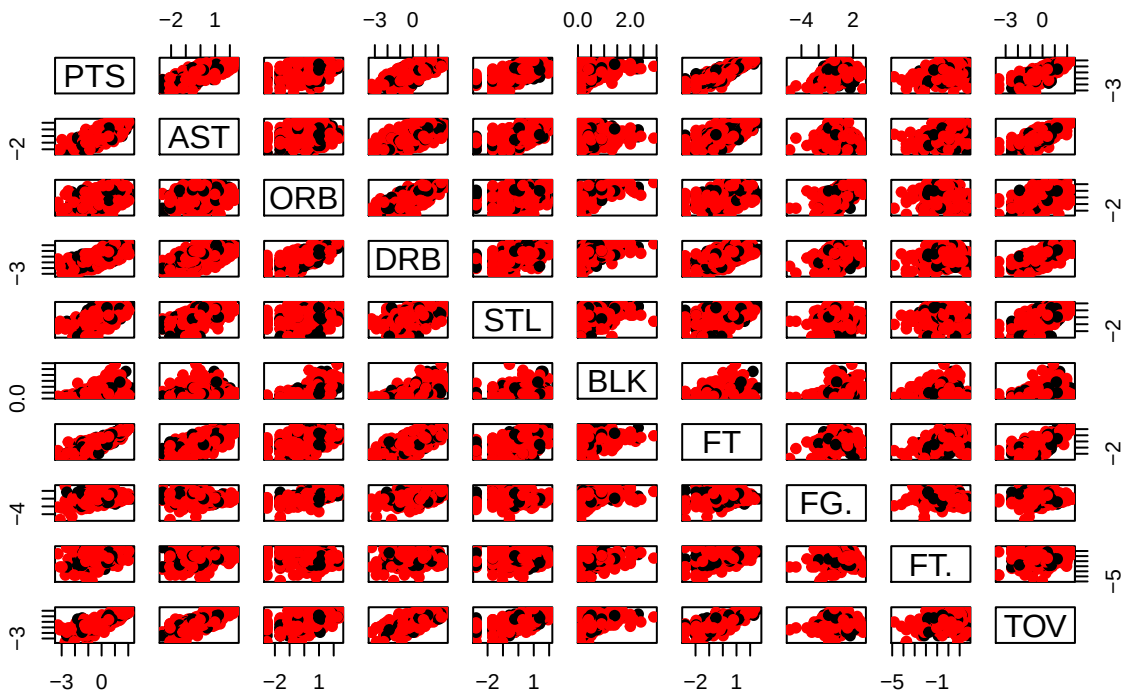
```
##               C            F            G
## 1 9.907129e-01 0.0092871209 7.503159e-09
## 2 9.388355e-01 0.0611644849 5.887126e-09
## 3 9.971079e-01 0.0028921045 1.452565e-17
## 4 8.123291e-06 0.0110820487 9.889098e-01
## 5 3.818039e-05 0.0306627055 9.692991e-01
## 6 9.990595e-01 0.0009404764 1.193614e-13
```

```
## [1] C C C G G C
## Levels: C F G
```




```
##
## pred.qda   C   F   G
##        C  98  23   0
##        F  14 158  24
##        G   4  38 181

## [1] 0.1907407
```



Performance is quite bad because the we use the same training and predict data set and it could be so optimistic. With k-cross validation the results are:

```
## [1] "confusion matrix"
```

```
##
## Label   C   F   G
##     C  93  19   4
##     F  27 148  44
##     G   1  34 170
```

```
## [1] "error percentage"
```

```
## [1] 0.2388889
```

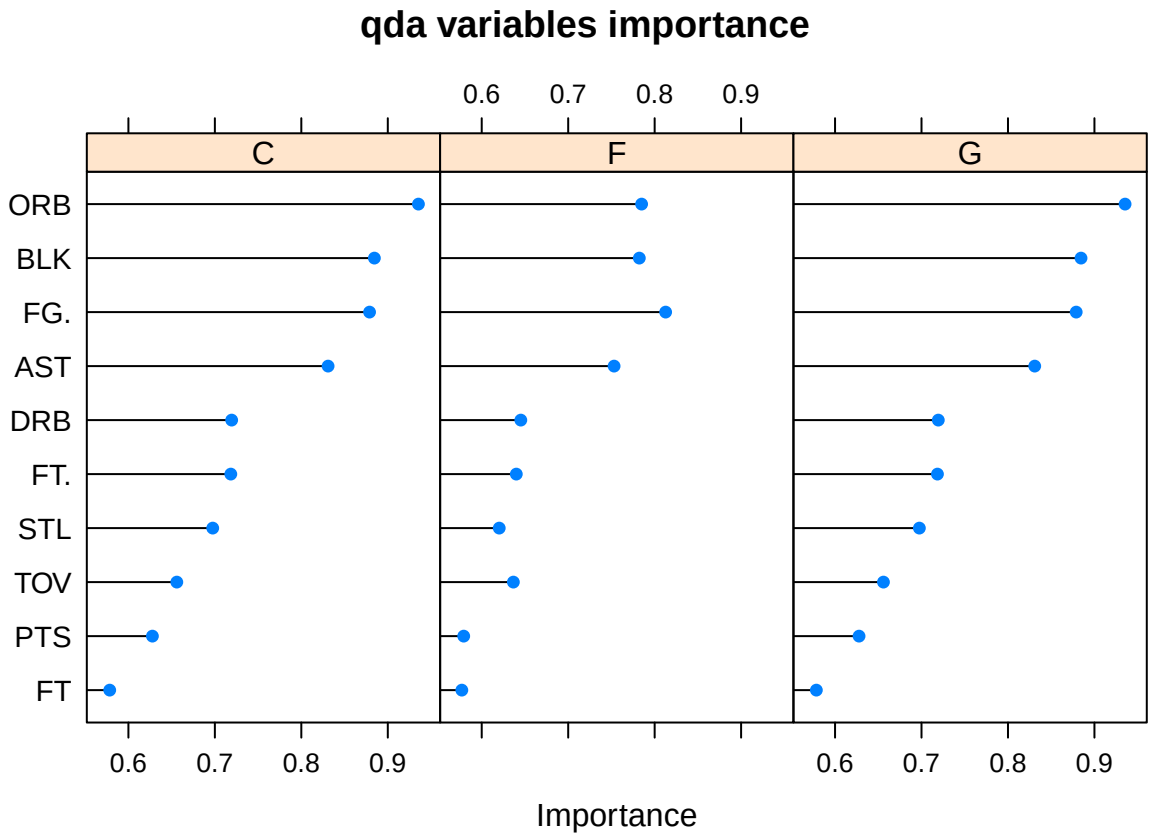
The error now is acceptable beacuase with cross validation we get a more realistic error.

In the next step will divide the data in training and test set. I will use 10-fold cross validation and I repeated it five times.

```
## [1] "qda results"
```

```
## Confusion Matrix and Statistics
##
##           Reference
```

```
## Prediction  C  F  G
##          C 22  3  1
##          F 10 43  6
##          G  2 19 54
##
## Overall Statistics
##
##                Accuracy : 0.7438
##                  95% CI : (0.6688, 0.8094)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.5977
##
##  Mcnemar's Test P-Value : 0.01249
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.6471   0.6615   0.8852
## Specificity            0.9683   0.8316   0.7879
## Pos Pred Value         0.8462   0.7288   0.7200
## Neg Pred Value         0.9104   0.7822   0.9176
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1375   0.2687   0.3375
## Detection Prevalence   0.1625   0.3688   0.4688
## Balanced Accuracy      0.8077   0.7466   0.8366
```



The accuracy is acceptable. Kappa is not good, but we work with balance groups so its not important. Afterwards, we do the same with step QDA.

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59807;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73168;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.65

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59613;  in: "ORB";  variables (1): ORB
## correctness rate: 0.70487;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64
```

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58672;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72714;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.75

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59101;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72269;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##         0.0         0.0         0.7

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59235;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73034;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.72

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59689;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72227;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.
```

```
## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57899;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71336;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.92

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58773;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71336;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57899;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72513;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.75

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59748;  in: "ORB";  variables (1): ORB
## correctness rate: 0.7179;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.78

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.

## correctness rate: 0.58815;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72815;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.69

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58319;  in: "ORB";  variables (1): ORB
## correctness rate: 0.75361;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.66

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.60647;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71101;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.68

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58017;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71126;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.63

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.59059;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73059;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58319;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71832;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59227;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72126;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.61

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59639;  in: "ORB";  variables (1): ORB
## correctness rate: 0.70798;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.63

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.59336;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72513;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58891;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72924;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57588;  in: "ORB";  variables (1): ORB
## correctness rate: 0.70765;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58462;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71311;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.72

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.60202;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72521;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.69

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58487;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73403;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57176;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72319;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.63

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58958;  in: "ORB";  variables (1): ORB
## correctness rate: 0.7216;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.60109;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72622;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.69

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.61714;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73445;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##         0.0         0.0         0.7

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57916;  in: "ORB";  variables (1): ORB
## correctness rate: 0.7284;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.69

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58361;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72454;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.66

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.58672;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71261;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##         0.0         0.0         0.7
```

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.
```

```
## 343 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.58672;  in: "ORB";  variables (1): ORB
## correctness rate: 0.70588;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.72
```

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.
```

```
## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.6;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71924;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67
```

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.
```

```
## 343 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.60933;  in: "ORB";  variables (1): ORB
## correctness rate: 0.7316;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.75
```

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.
```

```
## 343 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.59176;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72294;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.86

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.60084;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72126;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.72

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58109;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73084;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.72

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58882;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73773;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.59345;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72496;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 340 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58235;  in: "ORB";  variables (1): ORB
## correctness rate: 0.70294;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.61

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.60185;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72815;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.57866;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73681;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.67

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.58773;  in: "ORB";  variables (1): ORB
## correctness rate: 0.73706;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.69

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59773;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72303;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##         0.0         0.0         0.7

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58739;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71303;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.74

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.60202;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72218;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.68

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 340 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.58824;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71765;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58168;  in: "ORB";  variables (1): ORB
## correctness rate: 0.71076;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.71

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.58765;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72807;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.62

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

## correctness rate: 0.59244;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72303;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.64

##  'stepwise classification', using 10-fold cross-validated correctness rate of method qda'.

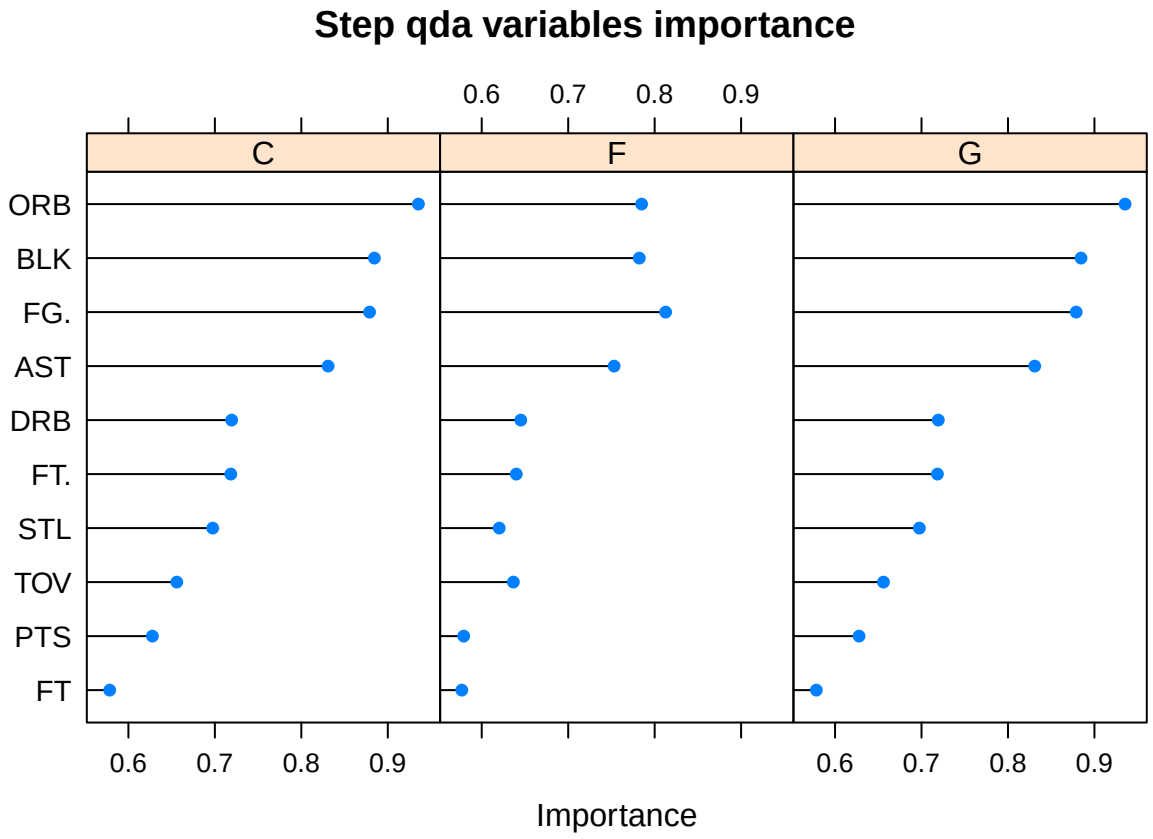
## 380 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

```
## correctness rate: 0.58684;  in: "ORB";  variables (1): ORB
## correctness rate: 0.72368;  in: "AST";  variables (2): ORB, AST
##
##  hr.elapsed min.elapsed sec.elapsed
##        0.00        0.00        0.71
```

```
## [1] "step qda results"
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 19  4  0
##          F 13 45 11
##          G  2 16 50
##
## Overall Statistics
##
##                Accuracy : 0.7125
##                  95% CI : (0.6357, 0.7812)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : 4.495e-15
##
##                   Kappa : 0.5453
##
##  Mcnemar's Test P-Value : 0.05286
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.5588   0.6923   0.8197
## Specificity            0.9683   0.7474   0.8182
## Pos Pred Value         0.8261   0.6522   0.7353
## Neg Pred Value         0.8905   0.7802   0.8804
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1187   0.2812   0.3125
## Detection Prevalence   0.1437   0.4313   0.4250
## Balanced Accuracy      0.7635   0.7198   0.8189
```

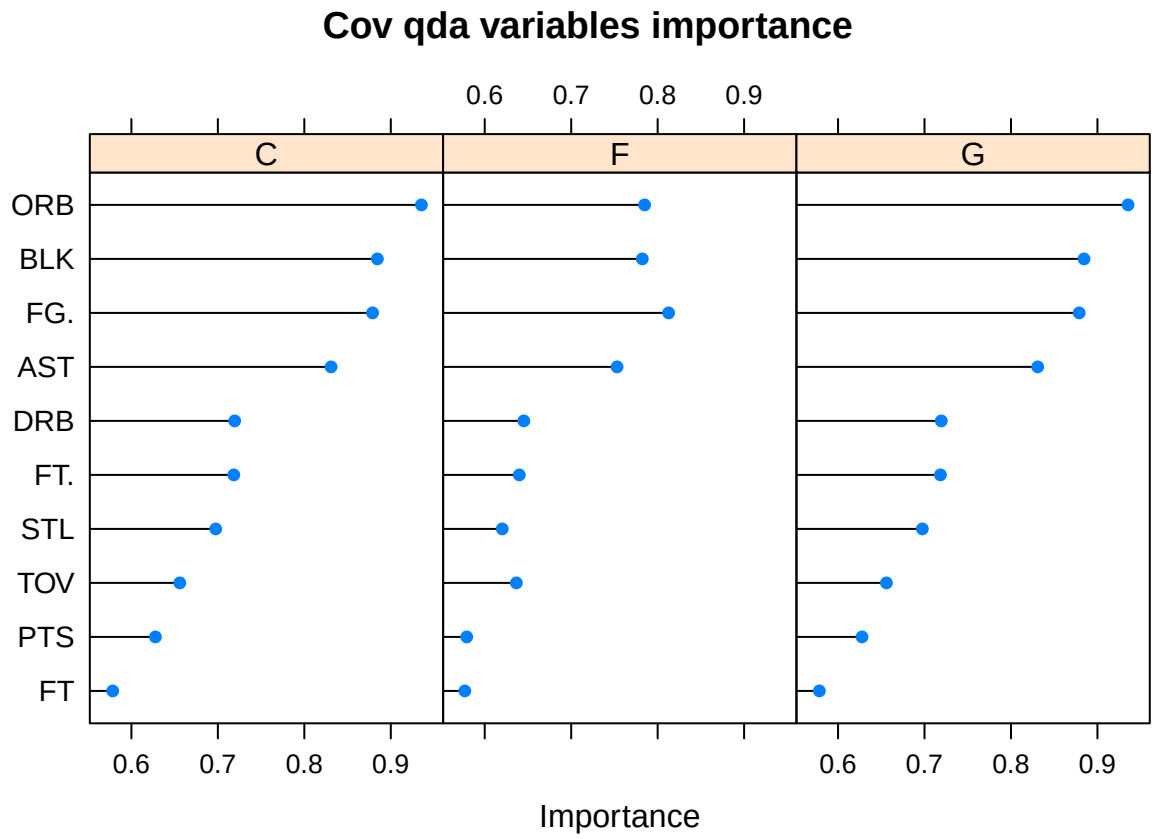


Step QDA performance worse. Now I check QDACOV method

```
## [1] "Covqda results"
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 22  4  3
##          F 11 45 14
##          G  1 16 44
##
## Overall Statistics
##
##                Accuracy : 0.6938
##                  95% CI : (0.6161, 0.7641)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : 1.897e-13
##
##                   Kappa : 0.5203
##
##  Mcnemar's Test P-Value : 0.2214
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
```

```
## Sensitivity            0.6471   0.6923   0.7213
## Specificity            0.9444   0.7368   0.8283
## Pos Pred Value         0.7586   0.6429   0.7213
## Neg Pred Value         0.9084   0.7778   0.8283
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1375   0.2812   0.2750
## Detection Prevalence   0.1812   0.4375   0.3812
## Balanced Accuracy      0.7958   0.7146   0.7748
```

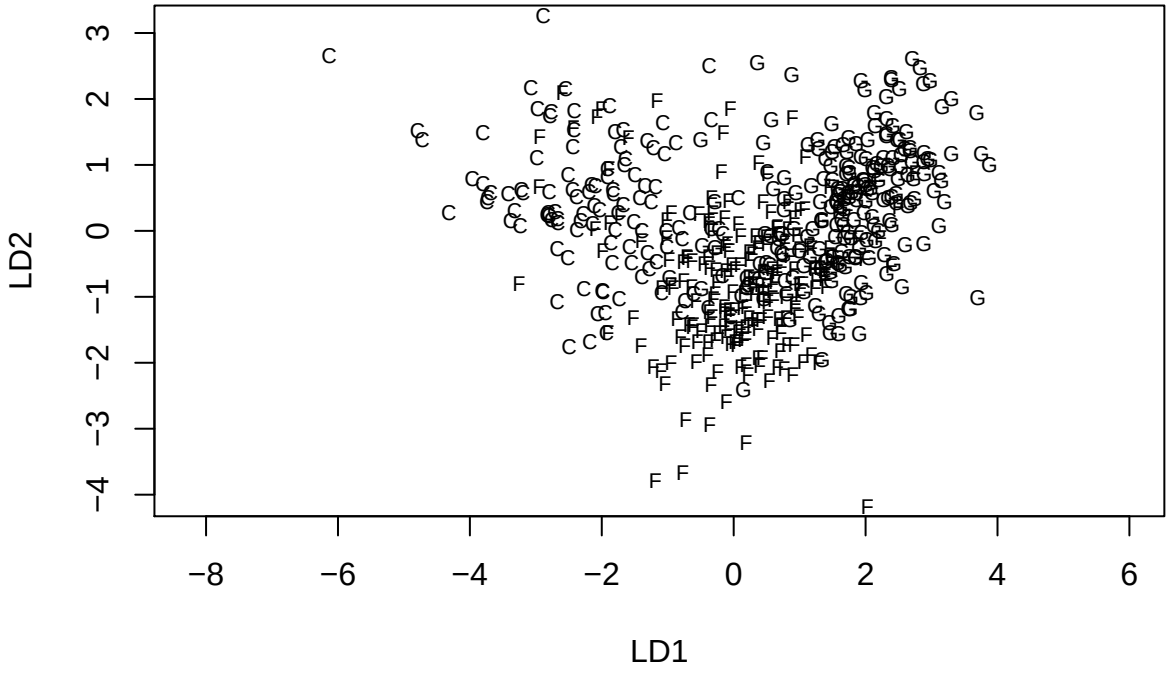


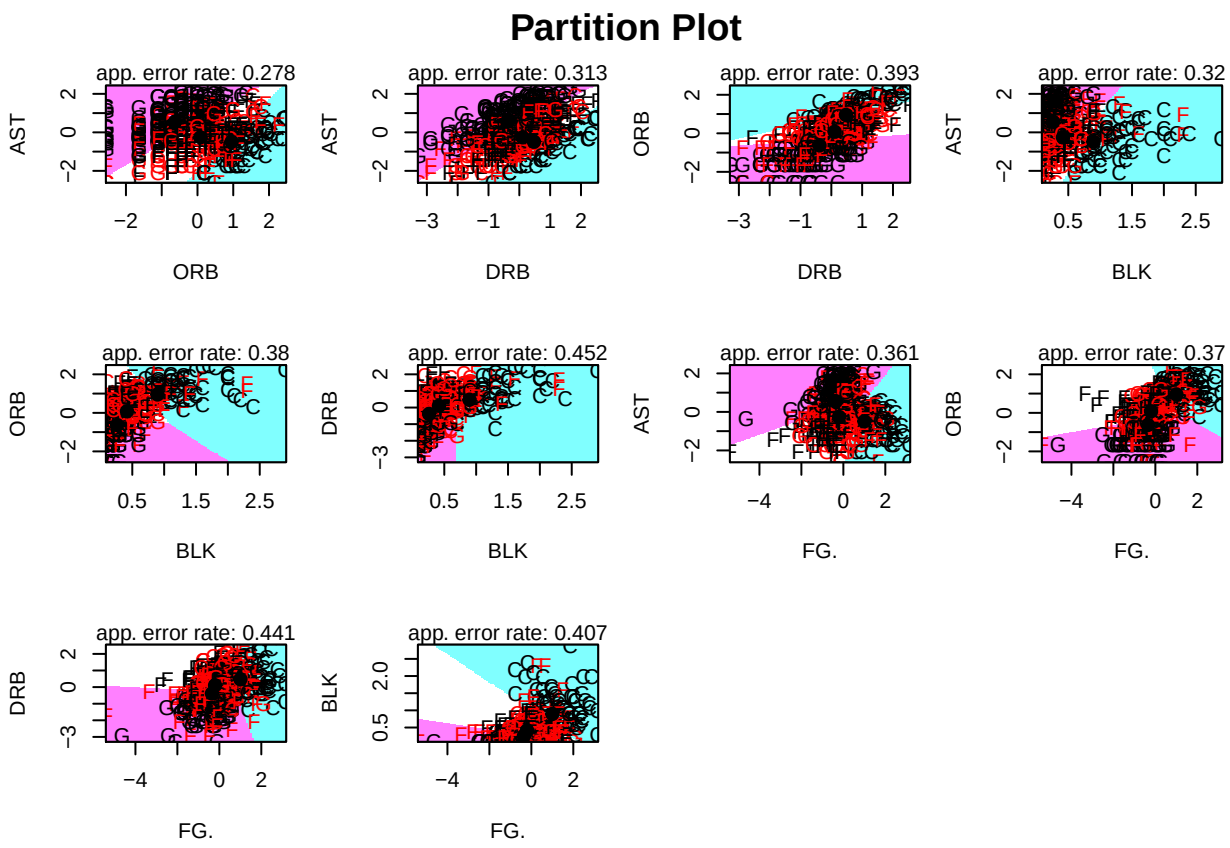
The results are satisfactory. I get the best results with simple qda. It should be noted that the percentage of success has a greater importance than what we predicted. Now do the same with LDA. I have done many preprocess that must improve the LDA performance; I have removed the outliers, I have standardized the data and have taken logarithm in order to get normality.

Now do the same with LDA

```
## Call:
## lda(Pos ~ ., data = my_data, prior = c(1, 1, 1)/3)
##
## Prior probabilities of groups:
##         C         F         G
## 0.3333333 0.3333333 0.3333333
##
## Group means:
##          PTS        AST         ORB        DRB         STL       BLK
## C -0.1373697 -0.4877953  0.95494088  0.4738070 -0.35065868 0.8956897
```

```
## F -0.1194755 -0.2591698  0.08156008  0.1081612 -0.04210344 0.4164384
## G  0.2053659  0.5528899 -0.62748683 -0.3836532  0.24340029 0.2614634
##              FT        FG.         FT.        TOV
## C  0.004483949  1.0057331 -0.39450965 -0.0792695
## F -0.127186069 -0.2033194 -0.05160357 -0.2197642
## G  0.133334688 -0.3518932  0.27836244  0.2796274
##
## Coefficients of linear discriminants:
##            LD1        LD2
## PTS  0.5899615 -0.2635144
## AST  0.5834233  0.7993311
## ORB -0.4925039 -0.1748154
## DRB -0.6142311 -1.1544371
## STL  0.2826530 -0.2759892
## BLK -1.3959356  1.7342830
## FT  -0.2255711 -0.1070718
## FG. -0.3923970  0.7438063
## FT. -0.0118821  0.1498016
## TOV  0.1226613  0.7062622
##
## Proportion of trace:
##    LD1    LD2
## 0.8891 0.1109
```

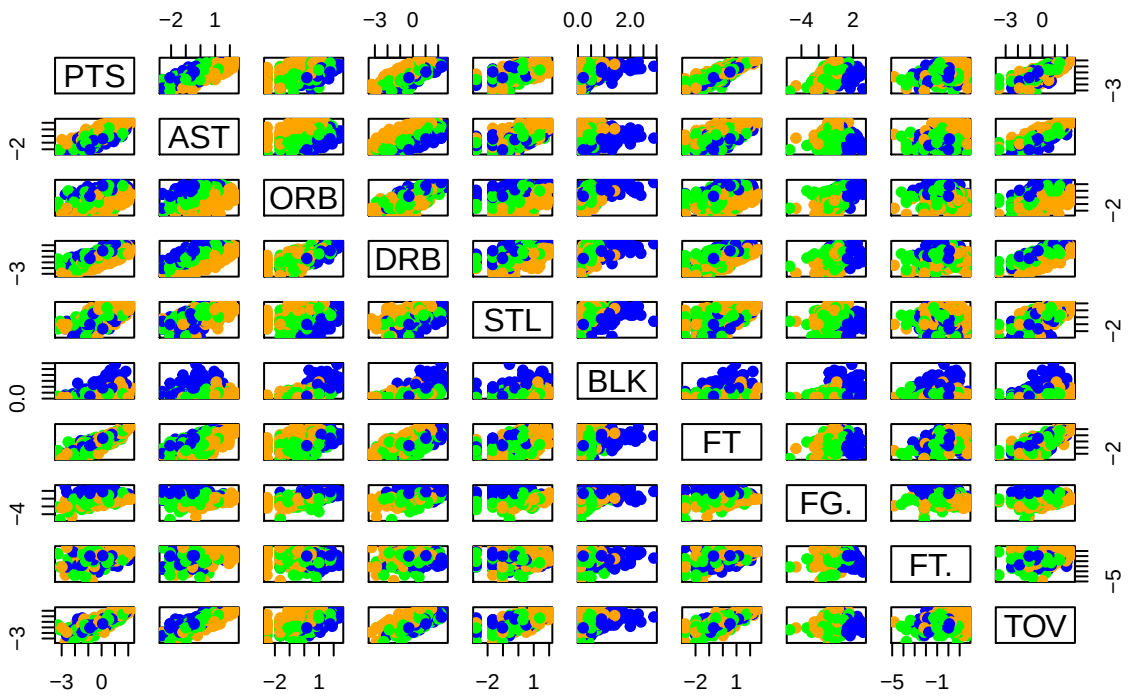




Conclusion are similar than with qda.

```
##              C           F            G
## 1 0.9784918778 0.021327484 1.806382e-04
## 2 0.9579747522 0.038578740 3.446508e-03
## 3 0.9649085082 0.034051698 1.039794e-03
## 4 0.0001040158 0.038289740 9.616062e-01
## 5 0.0020770588 0.148464158 8.494588e-01
## 6 0.9974870104 0.002509018 3.971667e-06
```

```
## [1] C C C G G C
## Levels: C F G
```




```
##
## pred.lda   C   F   G
##        C  97  21   1
##        F  18 165  33
##        G   1  33 171
```

```
## [1] 0.1981481
```

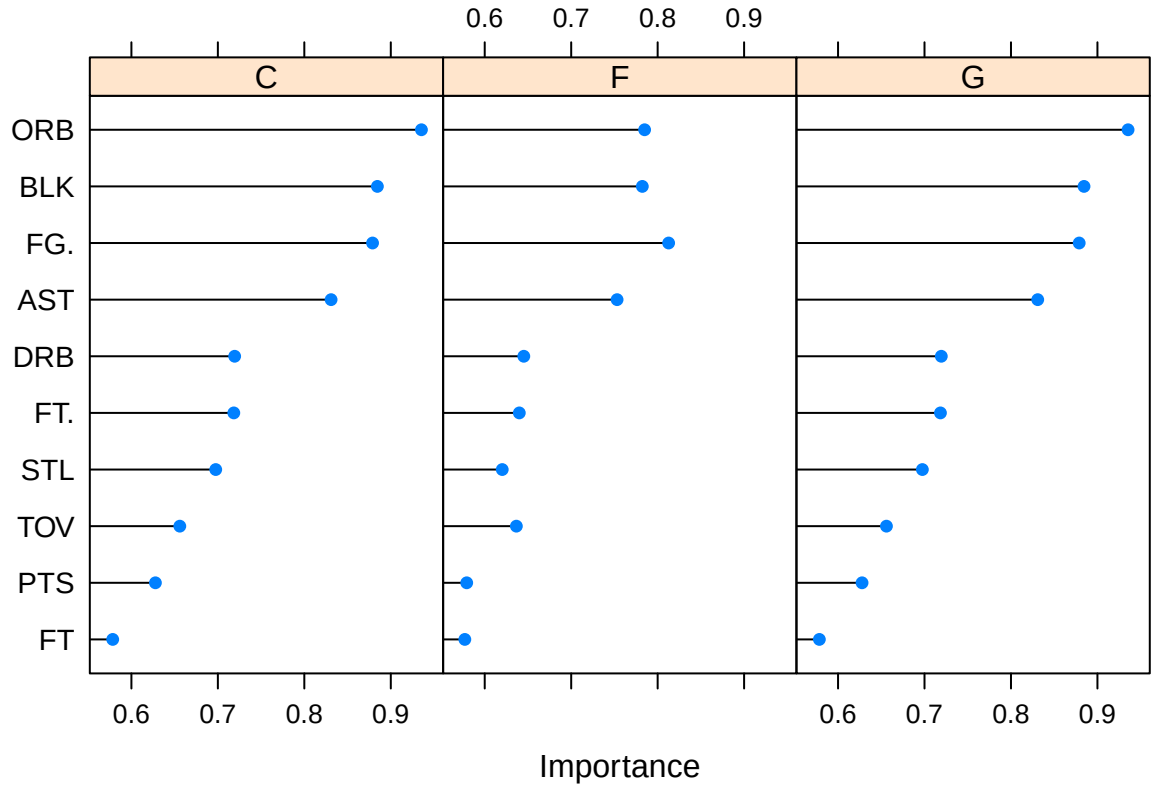
The performance is similar even though we simplify the model

```
##
## Label   C   F   G
##     C  97  18   1
##     F  22 159  38
##     G   1  33 171
```

```
## [1] 0.2092593
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 23  1  1
##          F 10 50  8
```

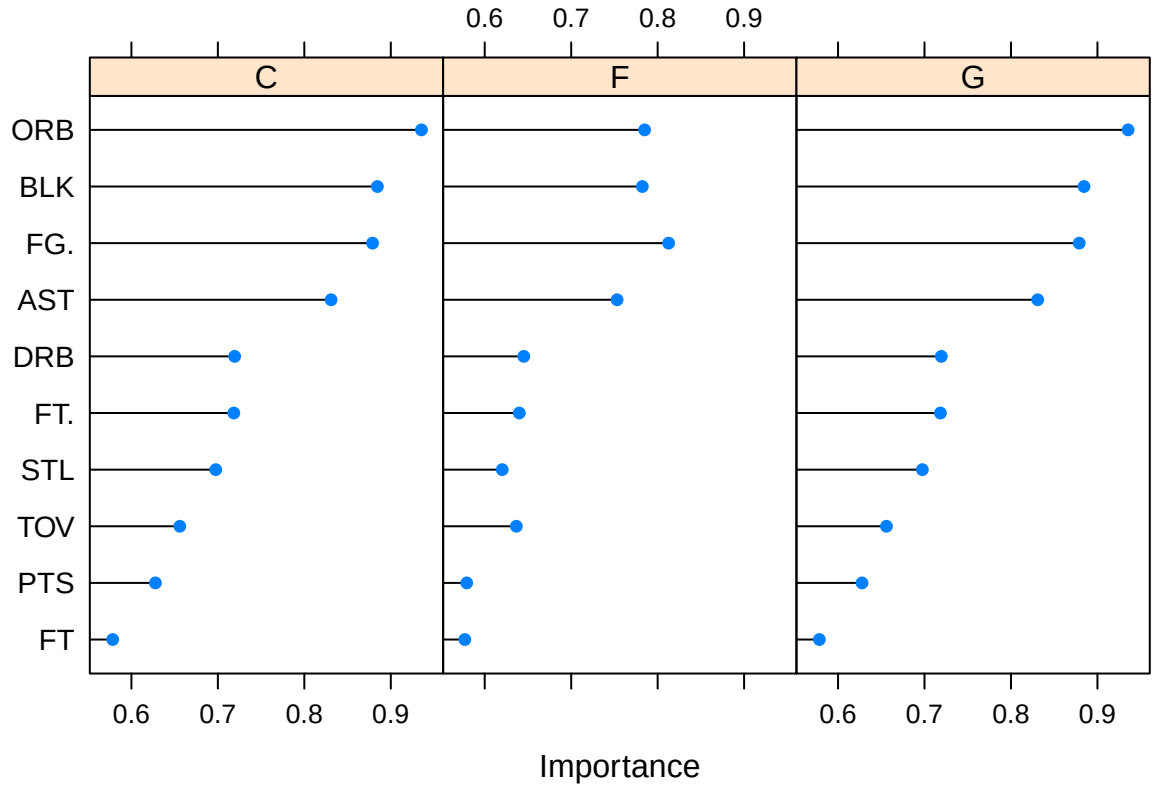
```
##          G  1 14 52
##
## Overall Statistics
##
##                Accuracy : 0.7812
##                  95% CI : (0.7091, 0.8427)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.6552
##
##  Mcnemar's Test P-Value : 0.02929
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.6765   0.7692   0.8525
## Specificity            0.9841   0.8105   0.8485
## Pos Pred Value         0.9200   0.7353   0.7761
## Neg Pred Value         0.9185   0.8370   0.9032
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1437   0.3125   0.3250
## Detection Prevalence   0.1562   0.4250   0.4188
## Balanced Accuracy      0.8303   0.7899   0.8505
```



With LDA I get the best accuracy and kappa because the preprocessing was good. I will use instead of LDA

sparseLDA.

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 25  7  1
##          F  6 41  6
##          G  3 17 54
##
## Overall Statistics
##
##                Accuracy : 0.75
##                  95% CI : (0.6755, 0.815)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.6126
##
##  Mcnemar's Test P-Value : 0.09628
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.7353   0.6308   0.8852
## Specificity            0.9365   0.8737   0.7980
## Pos Pred Value         0.7576   0.7736   0.7297
## Neg Pred Value         0.9291   0.7757   0.9186
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1562   0.2562   0.3375
## Detection Prevalence   0.2062   0.3312   0.4625
## Balanced Accuracy      0.8359   0.7522   0.8416
```



The results with sparseLDA are slightly worse. Now we try stepLDA.

```
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 343 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 343 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 340 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
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## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
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## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
## ‘stepwise classification’, using 10-fold cross-validated correctness rate of method lda’.
## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 341 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 343 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
## stop criterion: improvement less than 5%.
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.
## 342 observations of 10 variables in 3 classes; direction: both
```

```
## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 341 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 342 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.

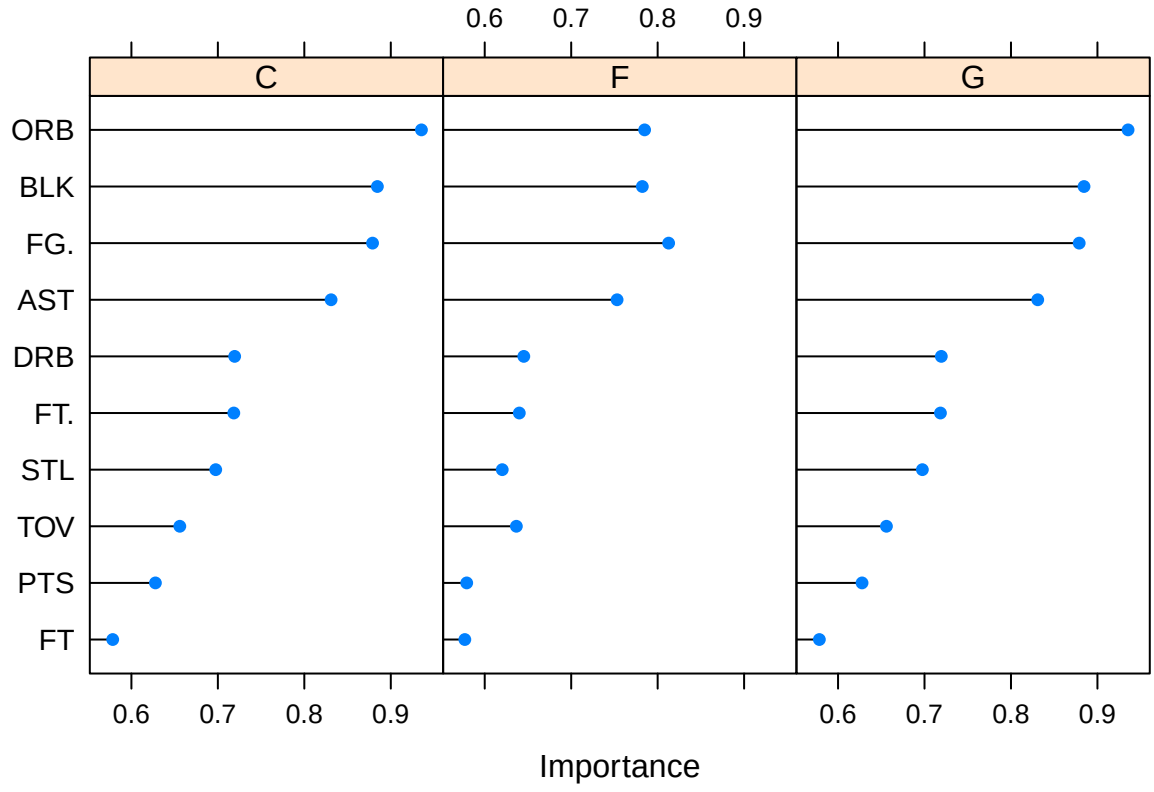
##  'stepwise classification', using 10-fold cross-validated correctness rate of method lda'.

## 380 observations of 10 variables in 3 classes; direction: both

## stop criterion: improvement less than 5%.
```

The results are worse. Now I make the same with naïve bayes With 10 kross validation repeated five times and divided in data and training sets. In this case, the variables are not enough independent.

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 17  4  0
##          F 16 47 11
##          G  1 14 50
##
## Overall Statistics
##
##                Accuracy : 0.7125
##                  95% CI : (0.6357, 0.7812)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : 4.495e-15
##
##                   Kappa : 0.5432
##
##  Mcnemar's Test P-Value : 0.03575
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.5000   0.7231   0.8197
## Specificity            0.9683   0.7158   0.8485
## Pos Pred Value         0.8095   0.6351   0.7692
## Neg Pred Value         0.8777   0.7907   0.8842
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1062   0.2938   0.3125
## Detection Prevalence   0.1313   0.4625   0.4062
## Balanced Accuracy      0.7341   0.7194   0.8341
```

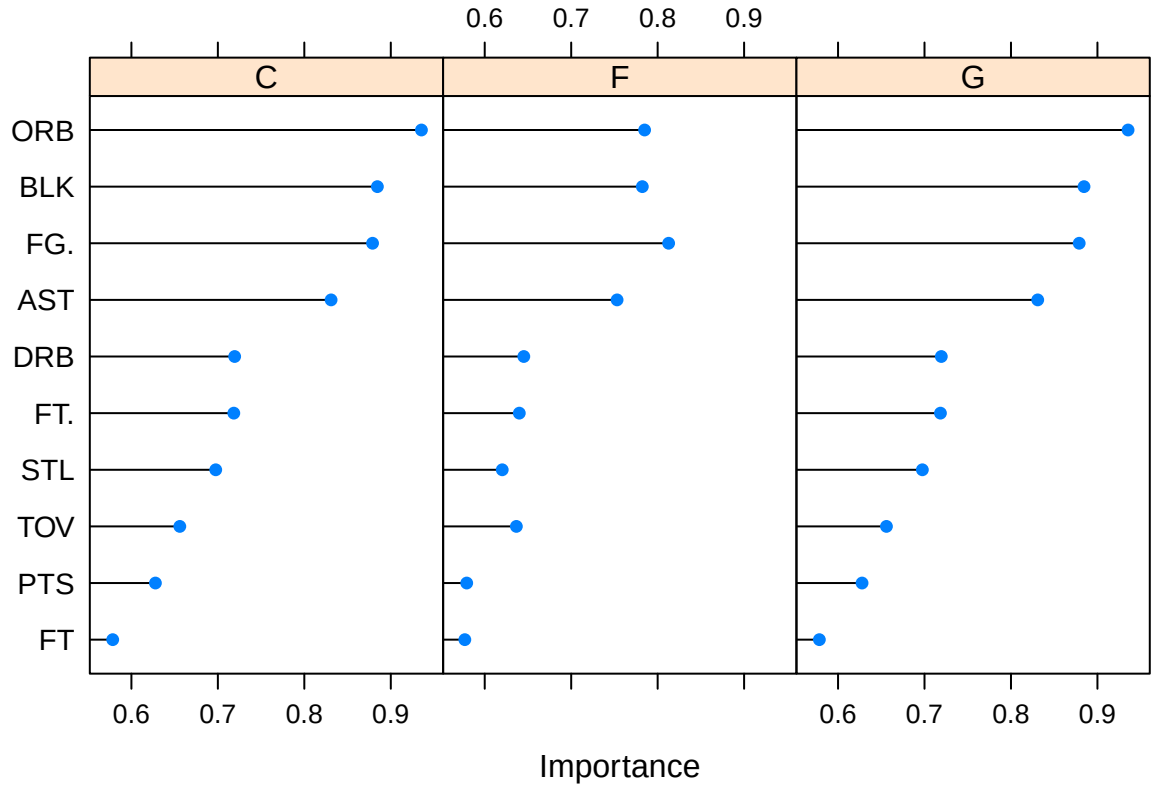



```
##
## Naive Bayes Classifier for Discrete Predictors
##
## Call:
## naiveBayes.default(x = X, y = Y, laplace = laplace, prior = ..1)
##
## A-priori probabilities:
## Y
##         C         F         G
## 0.2148148 0.4055556 0.3796296
##
## Conditional probabilities:
##    PTS
## Y         [,1]      [,2]
##   C -0.1373697 0.8911666
##   F -0.1194755 1.0485004
##   G  0.2053659 0.9753068
##
##    AST
## Y         [,1]      [,2]
##   C -0.4877953 0.8462439
##   F -0.2591698 0.8653787
##   G  0.5528899 0.9610346
##
##    ORB
## Y          [,1]      [,2]
```

```
##   C  0.95494088 0.7697166
##   F  0.08156008 0.8104696
##   G -0.62748683 0.8275755
##
##    DRB
## Y         [,1]      [,2]
##   C  0.4738070 0.9569118
##   F  0.1081612 0.9343943
##   G -0.3836532 0.9512258
##
##    STL
## Y          [,1]      [,2]
##   C -0.35065868 1.0256659
##   F -0.04210344 1.0302520
##   G  0.24340029 0.8851581
##
##    BLK
## Y        [,1]      [,2]
##   C 0.8956897 0.5430017
##   F 0.4164384 0.3226952
##   G 0.2614634 0.1672377
##
##    FT
## Y           [,1]      [,2]
##   C  0.004483949 0.8226755
##   F -0.127186069 1.0413285
##   G  0.133334688 1.0327659
##
##    FG.
## Y         [,1]      [,2]
##   C  1.0057331 0.9587157
##   F -0.2033194 0.9083714
##   G -0.3518932 0.7058828
##
##    FT.
## Y          [,1]      [,2]
##   C -0.39450965 0.9851809
##   F -0.05160357 1.0145908
##   G  0.27836244 0.9087090
##
##    TOV
## Y         [,1]      [,2]
##   C -0.0792695 0.8192115
##   F -0.2197642 1.0103941
##   G  0.2796274 1.0192563

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 21  2  0
##          F 12 50 11
##          G  1 13 50
##
```

```
## Overall Statistics
##
##                Accuracy : 0.7562
##                  95% CI : (0.6822, 0.8206)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.6141
##
##  Mcnemar's Test P-Value : 0.04003
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.6176   0.7692   0.8197
## Specificity            0.9841   0.7579   0.8586
## Pos Pred Value         0.9130   0.6849   0.7812
## Neg Pred Value         0.9051   0.8276   0.8854
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1313   0.3125   0.3125
## Detection Prevalence   0.1437   0.4562   0.4000
## Balanced Accuracy      0.8009   0.7636   0.8391
```




```
## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1
```

```
## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
## alpha >1; set to 1

## Warning in (function (x, y, family = c("gaussian", "binomial", "poisson", :
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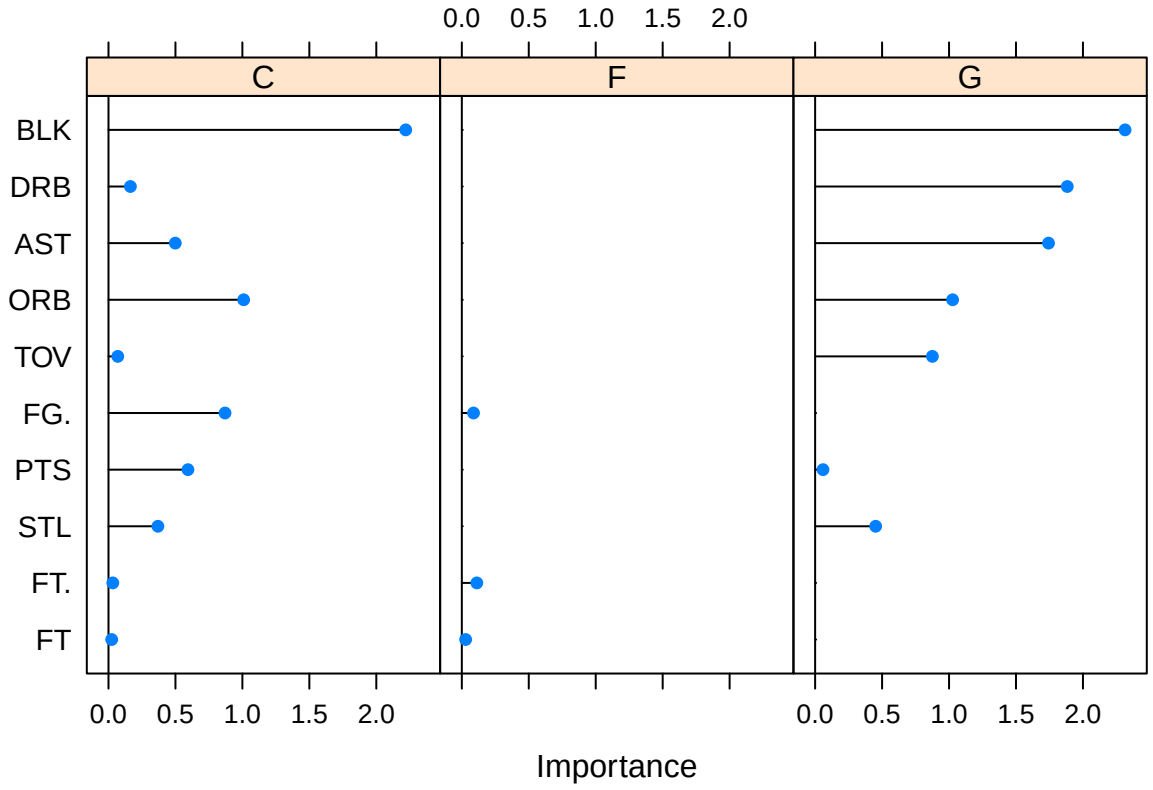
The results are worse than with LDA

Finally we finish with logistic regression. It works better with only two groups, but works acceptable with three. There are some variables like points per game and faults pero game that are not significant to classify and they introduce a large bias. Nevertheless, I introduce it inorder to compare all models with the same variables.

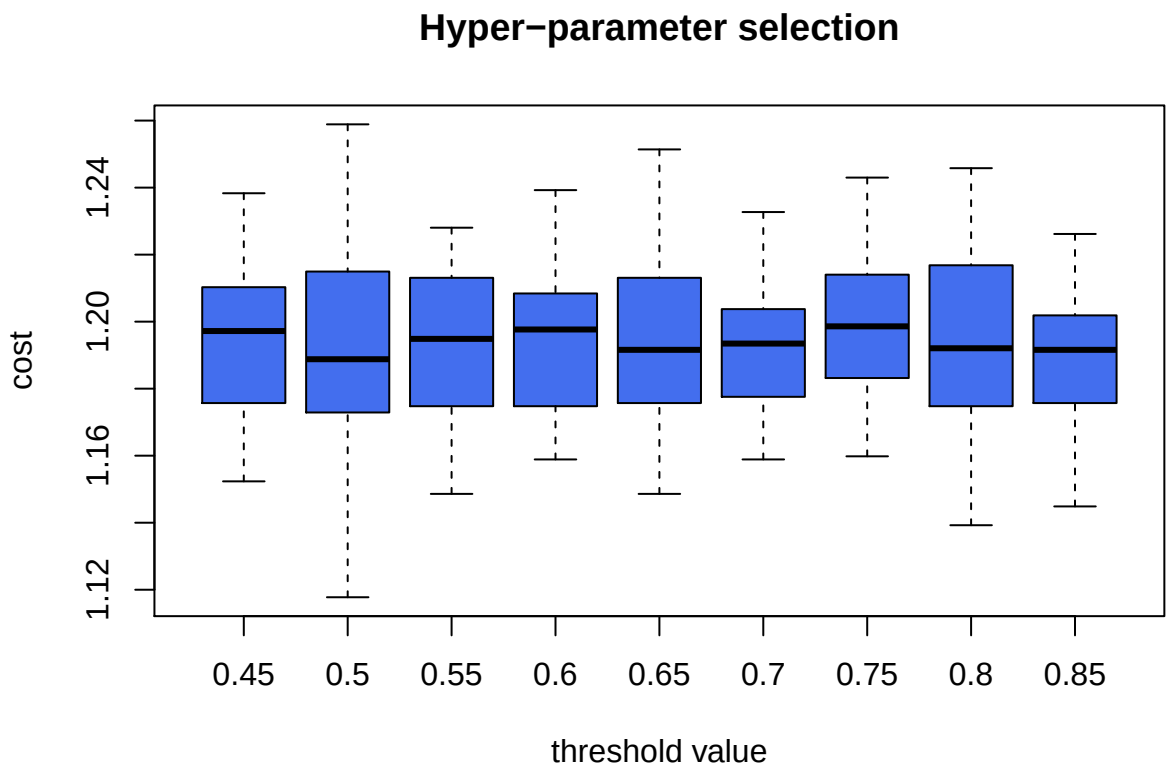
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  C  F  G
##          C 21  1  1
##          F 12 49  5
##          G  1 15 55
##
## Overall Statistics
##
##                Accuracy : 0.7812
##                  95% CI : (0.7091, 0.8427)
##     No Information Rate : 0.4062
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6543
##
##  Mcnemar's Test P-Value : 0.002515
##
## Statistics by Class:
##
##                      Class: C Class: F Class: G
## Sensitivity            0.6176   0.7538   0.9016
## Specificity            0.9841   0.8211   0.8384
## Pos Pred Value         0.9130   0.7424   0.7746
## Neg Pred Value         0.9051   0.8298   0.9326
## Prevalence             0.2125   0.4062   0.3812
## Detection Rate         0.1313   0.3063   0.3438
## Detection Prevalence   0.1437   0.4125   0.4437
## Balanced Accuracy      0.8009   0.7874   0.8700
```



With lda i have the best perofromance

Finally with best model(lda) I resume with cost-sensitive learning. Classify a guard like a center or viceversa is worse than classy a center or a guard like a foward beacuse sometimes fowars could play like a center or like a guard.Therefore, i will imput a bigger cost to this kind of failures.

```
## 123456789
```



The best performance is with threshold=0.6

```
##           Reference
## Prediction  C  F  G
##          C 22  5  1
##          F 11 45 11
##          G  1 15 49
```

```
## [1] "unitary cost"
```

```
## [1] 1.215625
```

‘‘‘