

# MVA.R

APEKSHA

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```
#ggplot2 is used to plot the bar plot
#install.packages("ggplot2")
library("ggplot2")
#corrplot is used to plot the correlation matrix
#install.packages("corrplot")
library("corrplot")
```

```
## corrplot 0.84 loaded
```

```
#It is used to reshape a one-dimensional array into a two-dimensional array with one column and multiple arrays.
#install.packages("reshape")
library("reshape")
```

```
## Warning: package 'reshape' was built under R version 3.5.2
```

```
#Reading the dataset
breast_cancer <- read.csv("C:\\Users\\APEKSHA\\Downloads\\wisc_bc_data.csv")

#Displaying the dataset using head function
head(breast_cancer)
```

```
##      id diagnosis radius_mean texture_mean perimeter_mean area_mean
## 1  87139402      B      12.32      12.39      78.85      464.1
## 2  8910251      B      10.60      18.95      69.28      346.4
## 3   905520      B      11.04      16.83      70.92      373.2
## 4   868871      B      11.28      13.39      73.00      384.8
## 5   9012568      B      15.19      13.21      97.65      711.8
## 6    906539      B      11.57      19.04      74.20      409.7
## smoothness_mean compactness_mean concavity_mean points_mean
## 1      0.10280      0.06981      0.03987      0.03700
## 2      0.09688      0.11470      0.06387      0.02642
## 3      0.10770      0.07804      0.03046      0.02480
## 4      0.11640      0.11360      0.04635      0.04796
## 5      0.07963      0.06934      0.03393      0.02657
## 6      0.08546      0.07722      0.05485      0.01428
## symmetry_mean dimension_mean radius_se texture_se perimeter_se area_se
## 1      0.1959      0.05955      0.2360      0.6656      1.670      17.43
## 2      0.1922      0.06491      0.4505      1.1970      3.430      27.10
## 3      0.1714      0.06340      0.1967      1.3870      1.342      13.54
## 4      0.1771      0.06072      0.3384      1.3430      1.851      26.33
## 5      0.1721      0.05544      0.1783      0.4125      1.338      17.72
## 6      0.2031      0.06267      0.2864      1.4400      2.206      20.30
## smoothness_se compactness_se concavity_se points_se symmetry_se
## 1      0.008045      0.011800      0.01683      0.012410      0.01924
## 2      0.007470      0.035810      0.03354      0.013650      0.03504
## 3      0.005158      0.009355      0.01056      0.007483      0.01718
## 4      0.011270      0.034980      0.02187      0.019650      0.01580
## 5      0.005012      0.014850      0.01551      0.009155      0.01647
## 6      0.007278      0.020470      0.04447      0.008799      0.01868
## dimension_se radius_worst texture_worst perimeter_worst area_worst
## 1      0.002248      13.50      15.64      86.97      549.1
## 2      0.003318      11.88      22.94      78.28      424.8
## 3      0.002198      12.41      26.44      79.93      471.4
## 4      0.003442      11.92      15.77      76.53      434.0
## 5      0.001767      16.20      15.73      104.50      819.1
## 6      0.003339      13.07      26.98      86.43      520.5
## smoothness_worst compactness_worst concavity_worst points_worst
## 1      0.1385      0.1266      0.12420      0.09391
## 2      0.1213      0.2515      0.19160      0.07926
## 3      0.1369      0.1482      0.10670      0.07431
## 4      0.1367      0.1822      0.08669      0.08611
## 5      0.1126      0.1737      0.13620      0.08178
## 6      0.1249      0.1937      0.25600      0.06664
## symmetry_worst dimension_worst
## 1      0.2827      0.06771
## 2      0.2940      0.07587
## 3      0.2998      0.07881
## 4      0.2102      0.06784
## 5      0.2487      0.06766
## 6      0.3035      0.08284
```

```
#Displays structure of the dataset
str(breast_cancer)
```

```
## 'data.frame':   569 obs. of  32 variables:
## $ id           : int  87139402 8910251 905520 868871 9012568 906539 925291 87880 862989 89827 ...
## $ diagnosis    : Factor w/ 2 levels "B","M": 1 1 1 1 1 1 1 2 1 1 ...
## $ radius_mean  : num  12.3 10.6 11 11.3 15.2 ...
## $ texture_mean : num  12.4 18.9 16.8 13.4 13.2 ...
## $ perimeter_mean : num  78.8 69.3 70.9 73 97.7 ...
## $ area_mean    : num  464 346 373 385 712 ...
## $ smoothness_mean : num  0.1028 0.0969 0.1077 0.1164 0.0796 ...
## $ compactness_mean : num  0.0698 0.1147 0.078 0.1136 0.0693 ...
## $ concavity_mean : num  0.0399 0.0639 0.0305 0.0464 0.0339 ...
## $ points_mean   : num  0.037 0.0264 0.0248 0.048 0.0266 ...
## $ symmetry_mean  : num  0.196 0.192 0.171 0.177 0.172 ...
## $ dimension_mean : num  0.0595 0.0649 0.0634 0.0607 0.0554 ...
## $ radius_se     : num  0.236 0.451 0.197 0.338 0.178 ...
## $ texture_se    : num  0.666 1.197 1.387 1.343 0.412 ...
## $ perimeter_se  : num  1.67 3.43 1.34 1.85 1.34 ...
## $ area_se       : num  17.4 27.1 13.5 26.3 17.7 ...
## $ smoothness_se : num  0.00805 0.00747 0.00516 0.01127 0.00501 ...
## $ compactness_se : num  0.0118 0.03581 0.00936 0.03498 0.01485 ...
## $ concavity_se  : num  0.0168 0.0335 0.0106 0.0219 0.0155 ...
## $ points_se     : num  0.01241 0.01365 0.00748 0.01965 0.00915 ...
## $ symmetry_se   : num  0.0192 0.035 0.0172 0.0158 0.0165 ...
## $ dimension_se  : num  0.00225 0.00332 0.0022 0.00344 0.00177 ...
## $ radius_worst  : num  13.5 11.9 12.4 11.9 16.2 ...
## $ texture_worst : num  15.6 22.9 26.4 15.8 15.7 ...
## $ perimeter_worst : num  87 78.3 79.9 76.5 104.5 ...
## $ area_worst    : num  549 425 471 434 819 ...
## $ smoothness_worst : num  0.139 0.121 0.137 0.137 0.113 ...
## $ compactness_worst : num  0.127 0.252 0.148 0.182 0.174 ...
## $ concavity_worst : num  0.1242 0.1916 0.1067 0.0867 0.1362 ...
## $ points_worst   : num  0.0939 0.0793 0.0743 0.0861 0.0818 ...
## $ symmetry_worst : num  0.283 0.294 0.3 0.21 0.249 ...
## $ dimension_worst : num  0.0677 0.0759 0.0788 0.0678 0.0677 ...
```

```
#Displays the names of the columns
names(breast_cancer)
```

```
## [1] "id"           "diagnosis"    "radius_mean"
## [4] "texture_mean" "perimeter_mean" "area_mean"
## [7] "smoothness_mean" "compactness_mean" "concavity_mean"
## [10] "points_mean"    "symmetry_mean"   "dimension_mean"
## [13] "radius_se"      "texture_se"      "perimeter_se"
## [16] "area_se"        "smoothness_se"   "compactness_se"
## [19] "concavity_se"   "points_se"       "symmetry_se"
## [22] "dimension_se"   "radius_worst"    "texture_worst"
## [25] "perimeter_worst" "area_worst"      "smoothness_worst"
## [28] "compactness_worst" "concavity_worst" "points_worst"
## [31] "symmetry_worst"  "dimension_worst"
```

```
#Displays the summary of the dataset
summary(breast_cancer)
```

```
##      id      diagnosis radius_mean texture_mean
## Min.   :    8670    B:357   Min.    : 6.981   Min.    : 9.71
## 1st Qu.:   869218    M:212   1st Qu.:11.700   1st Qu.:16.17
## Median :    906024             Median :13.370   Median :18.84
## Mean   :   30371831             Mean  :14.127   Mean    :19.29
## 3rd Qu.:   8813129             3rd Qu.:15.780   3rd Qu.:21.80
## Max.   :  911320502             Max.    :28.110   Max.    :39.28
## perimeter_mean area_mean smoothness_mean compactness_mean
## Min.    : 43.79   Min.    : 143.5   Min.    :0.05263   Min.    :0.01938
## 1st Qu.: 75.17   1st Qu.: 420.3   1st Qu.:0.08637   1st Qu.:0.06492
## Median : 86.24   Median : 551.1   Median :0.09587   Median :0.09263
## Mean    : 91.97   Mean    : 654.9   Mean    :0.09636   Mean    :0.10434
## 3rd Qu.:104.10   3rd Qu.: 782.7   3rd Qu.:0.10530   3rd Qu.:0.13040
## Max.    :188.50   Max.    :2501.0   Max.    :0.16340   Max.    :0.34540
## concavity_mean points_mean symmetry_mean dimension_mean
## Min.    :0.00000   Min.    :0.00000   Min.    :0.1060   Min.    :0.04996
## 1st Qu.:0.02956   1st Qu.:0.02031   1st Qu.:0.1619   1st Qu.:0.05770
## Median :0.06154   Median :0.03350   Median :0.1792   Median :0.06154
## Mean    :0.08880   Mean    :0.04892   Mean    :0.1812   Mean    :0.06280
## 3rd Qu.:0.13070   3rd Qu.:0.07400   3rd Qu.:0.1957   3rd Qu.:0.06612
## Max.    :0.42680   Max.    :0.20120   Max.    :0.3040   Max.    :0.09744
## radius_se texture_se perimeter_se area_se
## Min.    :0.1115   Min.    :0.3602   Min.    : 0.757   Min.    : 6.802
## 1st Qu.:0.2324   1st Qu.:0.8339   1st Qu.: 1.606   1st Qu.:17.850
## Median :0.3242   Median :1.1080   Median : 2.287   Median :24.530
## Mean    :0.4052   Mean    :1.2169   Mean    : 2.866   Mean    :40.337
## 3rd Qu.:0.4789   3rd Qu.:1.4740   3rd Qu.: 3.357   3rd Qu.:45.190
## Max.    :2.8730   Max.    :4.8850   Max.    :21.980   Max.    :542.200
## smoothness_se compactness_se concavity_se
## Min.    :0.001713   Min.    :0.002252   Min.    :0.00000
## 1st Qu.:0.005169   1st Qu.:0.013080   1st Qu.:0.01509
## Median :0.006380   Median :0.020450   Median :0.02589
## Mean    :0.007041   Mean    :0.025478   Mean    :0.03189
## 3rd Qu.:0.008146   3rd Qu.:0.032450   3rd Qu.:0.04205
## Max.    :0.031130   Max.    :0.135400   Max.    :0.39600
## points_se symmetry_se dimension_se radius_worst
## Min.    :0.000000   Min.    :0.007882   Min.    :0.0008948   Min.    : 7.93
## 1st Qu.:0.007638   1st Qu.:0.015160   1st Qu.:0.0022480   1st Qu.:13.01
## Median :0.010930   Median :0.018730   Median :0.0031870   Median :14.97
## Mean    :0.011796   Mean    :0.020542   Mean    :0.0037949   Mean    :16.27
## 3rd Qu.:0.014710   3rd Qu.:0.023480   3rd Qu.:0.0045580   3rd Qu.:18.79
## Max.    :0.052790   Max.    :0.078950   Max.    :0.0298400   Max.    :36.04
## texture_worst perimeter_worst area_worst smoothness_worst
## Min.    :12.02   Min.    : 50.41   Min.    :185.2   Min.    :0.07117
## 1st Qu.:21.08   1st Qu.: 84.11   1st Qu.:515.3   1st Qu.:0.11660
## Median :25.41   Median : 97.66   Median :686.5   Median :0.13130
## Mean    :25.68   Mean    :107.26   Mean    :880.6   Mean    :0.13237
## 3rd Qu.:29.72   3rd Qu.:125.40   3rd Qu.:1084.0   3rd Qu.:0.14600
## Max.    :49.54   Max.    :251.20   Max.    :4254.0   Max.    :0.22260
## compactness_worst concavity_worst points_worst symmetry_worst
## Min.    :0.02729   Min.    :0.0000   Min.    :0.00000   Min.    :0.1565
## 1st Qu.:0.14720   1st Qu.:0.1145   1st Qu.:0.06493   1st Qu.:0.2504
## Median :0.21190   Median :0.2267   Median :0.09993   Median :0.2822
## Mean    :0.25427   Mean    :0.2722   Mean    :0.11461   Mean    :0.2901
## 3rd Qu.:0.33910   3rd Qu.:0.3829   3rd Qu.:0.16140   3rd Qu.:0.3179
## Max.    :1.05800   Max.    :1.2520   Max.    :0.29100   Max.    :0.6638
## dimension_worst
## Min.    :0.05504
## 1st Qu.:0.07146
## Median :0.08004
## Mean    :0.08395
## 3rd Qu.:0.09208
## Max.    :0.20750
```

```
#To display the frequency table
```

```
diagnosis.table <- table(breast_cancer$diagnosis)
```

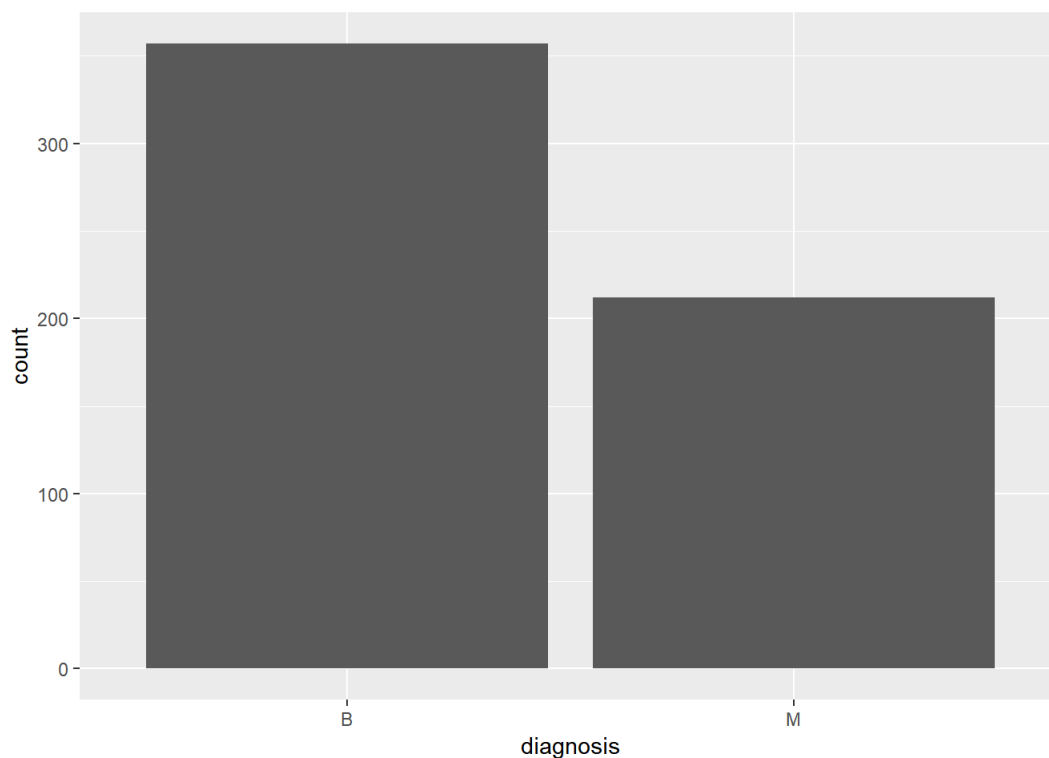
```
#Displays the table
```

```
#This shows how many patients are benign and malignant
```

```
diagnosis.table
```

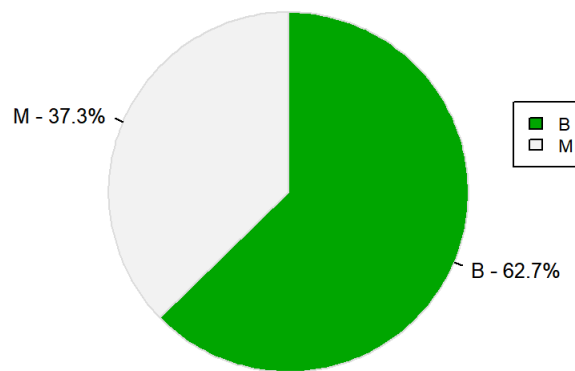
```
##  
##    B    M  
## 357 212
```

```
#Generate barplot  
ggplot(data=breast_cancer, aes(x=diagnosis)) + geom_bar(stat = "count")
```



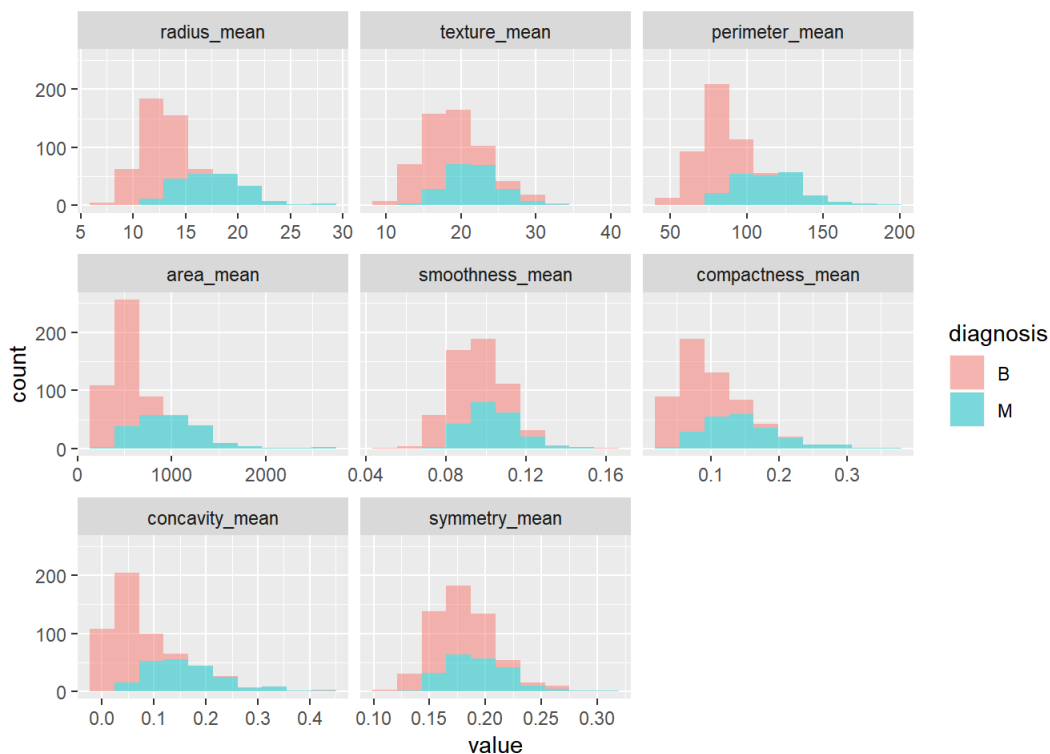
```
#Generate Pie chart represented in frequency  
diagnosis.prop.table <- prop.table(diagnosis.table)*100  
diagnosis.prop.df <- as.data.frame(diagnosis.prop.table)  
pielabels <- sprintf("%s - %3.1f%s", diagnosis.prop.df[,1], diagnosis.prop.table, "%")  
colors <- terrain.colors(2)  
pie(diagnosis.prop.table,  
    labels=pielabels,  
    clockwise=TRUE,  
    col=colors,  
    border="gainsboro",  
    radius=0.8,  
    cex=0.8,  
    main="frequency of cancer diagnosis")  
legend(1, .4, legend=diagnosis.prop.df[,1], cex = 0.7, fill = colors)
```

## frequency of cancer diagnosis



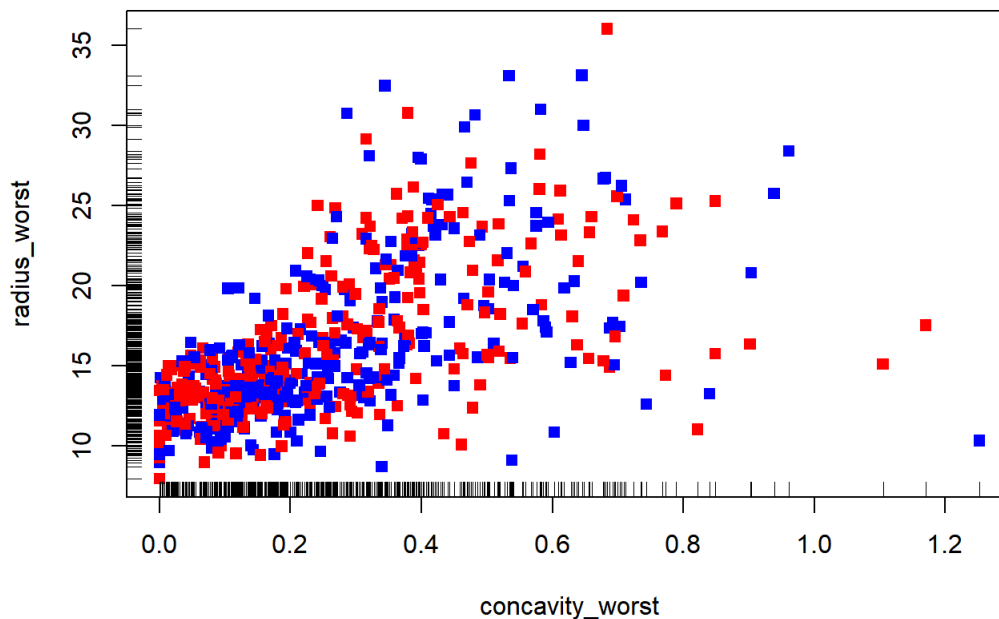
```
#To Plot histograms of "mean" variables group by diagnosis
data_mean <- breast_cancer[,c("diagnosis", "radius_mean", "texture_mean", "perimeter_mean", "area_mean", "smoothness_mean", "compactness_mean", "concavity_mean", "symmetry_mean")]
```

```
#Plot histograms
ggplot(data = melt(data_mean, id.var = "diagnosis"), mapping = aes(x = value)) +
  geom_histogram(bins = 10, aes(fill=diagnosis), alpha=0.5) + facet_wrap(~variable, scales = 'free_x')
```

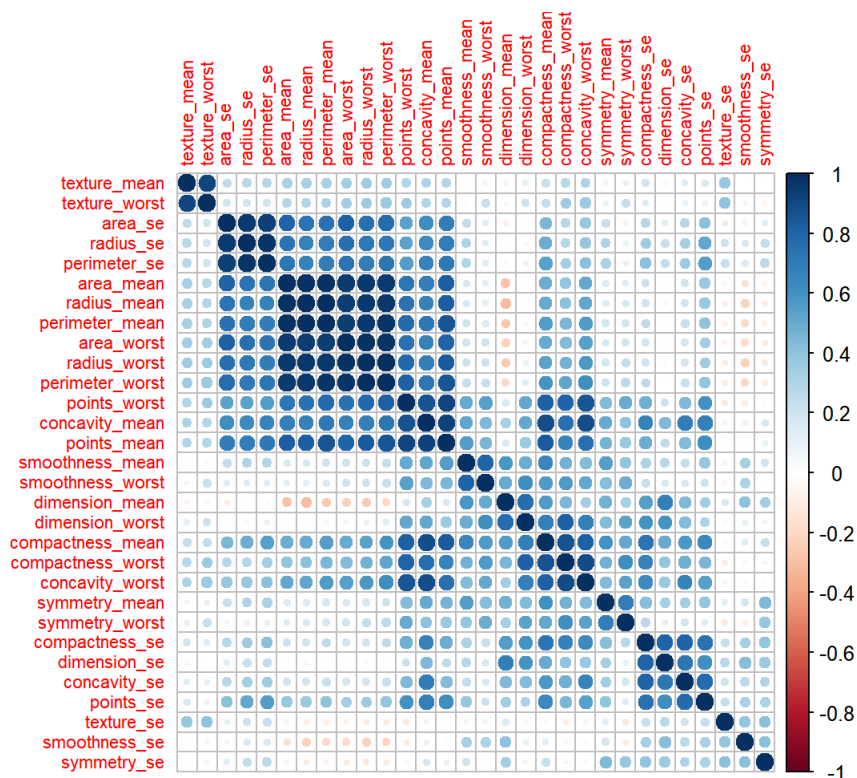


```
#Generate a Scatter plot of two variable ie. concavity against radius
data <- breast_cancer[,c('concavity_worst', 'radius_worst')]
plot(x = breast_cancer$concavity_worst, y = breast_cancer$radius_worst,
     xlab = "concavity_worst",
     ylab = "radius_worst",
     main = "Concavity_worst vs radius_worst",
     pch=15,
     col = c("red", "blue")
)
rug(breast_cancer$concavity_worst, side = 1)
rug(breast_cancer$radius_worst, side = 2)
```

Concavity\_worst vs radius\_worst

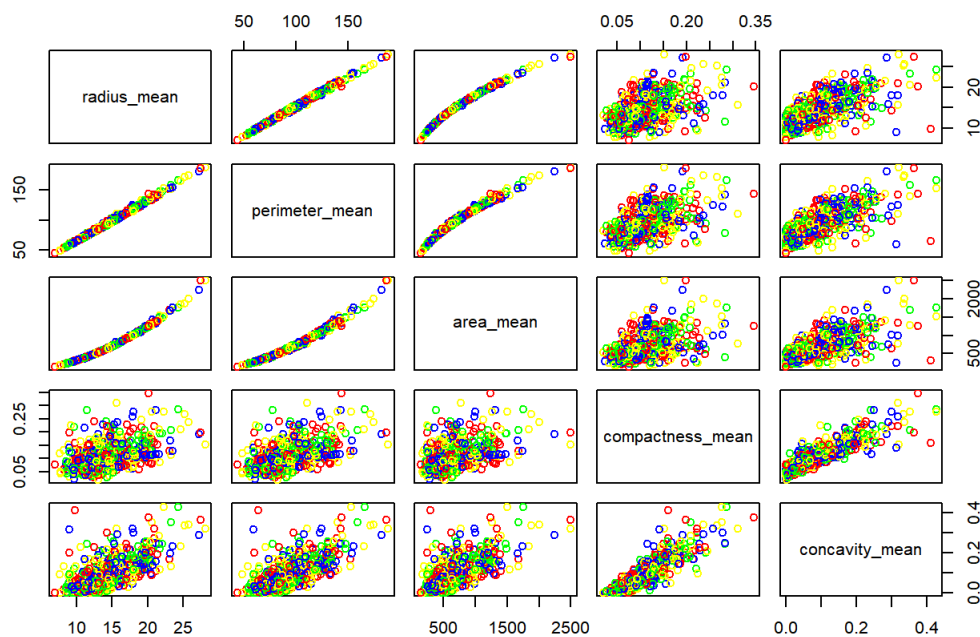


```
#Generate Correlation Matrix of columns
corMatMy <- cor(breast_cancer[,3:32])
corrplot(corMatMy, order = "hclust", tl.cex = 0.7)
```



```
#Generate Scatterplot Matrix
pairs(~radius_mean+perimeter_mean+area_mean+compactness_mean+concavity_mean,data = breast_cancer,main = "Scatterplot Matrix",col=c("red","blue","green","yellow"))
```

## Scatterplot Matrix



```
#Multivariate analysis
#t-tEST
with(data=breast_cancer,t.test(radius_mean[diagnosis=="B"],radius_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: radius_mean[diagnosis == "B"] and radius_mean[diagnosis == "M"]
## t = -25.436, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -5.726832 -4.905781
## sample estimates:
## mean of x mean of y
## 12.14652 17.46283
```

```
with(data=breast_cancer,t.test(texture_mean[diagnosis=="B"],texture_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: texture_mean[diagnosis == "B"] and texture_mean[diagnosis == "M"]
## t = -10.867, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -4.357107 -3.023181
## sample estimates:
## mean of x mean of y
## 17.91476 21.60491
```

```
with(data=breast_cancer,t.test(perimeter_mean[diagnosis=="B"],perimeter_mean[diagnosis=="M"],var.equal=TRUE)
)
```



```
##
## Two Sample t-test
##
## data: perimeter_mean[diagnosis == "B"] and perimeter_mean[diagnosis == "M"]
## t = -26.405, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -40.06379 -34.51615
## sample estimates:
## mean of x mean of y
## 78.07541 115.36538
```

```
with(data=breast_cancer,t.test(area_mean[diagnosis=="B"],area_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: area_mean[diagnosis == "B"] and area_mean[diagnosis == "M"]
## t = -23.939, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -557.8898 -473.2826
## sample estimates:
## mean of x mean of y
## 462.7902 978.3764
```

```
with(data=breast_cancer,t.test(smoothness_mean[diagnosis=="B"],smoothness_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: smoothness_mean[diagnosis == "B"] and smoothness_mean[diagnosis == "M"]
## t = -9.1461, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.012658756 -0.008182931
## sample estimates:
## mean of x mean of y
## 0.09247765 0.10289849
```

```
with(data=breast_cancer,t.test(compactness_mean[diagnosis=="B"],compactness_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: compactness_mean[diagnosis == "B"] and compactness_mean[diagnosis == "M"]
## t = -17.698, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.07232827 -0.05787805
## sample estimates:
## mean of x mean of y
## 0.08008462 0.14518778
```

```
with(data=breast_cancer,t.test(concavity_mean[diagnosis=="B"],concavity_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: concavity_mean[diagnosis == "B"] and concavity_mean[diagnosis == "M"]
## t = -23.104, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.1244696 -0.1049646
## sample estimates:
## mean of x mean of y
## 0.04605762 0.16077472
```

```
with(data=breast_cancer,t.test(points_mean[diagnosis=="B"],points_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: points_mean[diagnosis == "B"] and points_mean[diagnosis == "M"]
## t = -29.354, df = 567, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.06643938 -0.05810581
## sample estimates:
## mean of x mean of y
## 0.02571741 0.08799000
```

```
with(data=breast_cancer,t.test(symmetry_mean[diagnosis=="B"],symmetry_mean[diagnosis=="M"],var.equal=TRUE))
```

```
##
## Two Sample t-test
##
## data: symmetry_mean[diagnosis == "B"] and symmetry_mean[diagnosis == "M"]
## t = -8.3383, df = 567, p-value = 5.733e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.02313331 -0.01431262
## sample estimates:
## mean of x mean of y
## 0.174186 0.192909
```

```
with(data=breast_cancer,t.test(dimension_mean[diagnosis=="B"],dimension_mean[diagnosis=="M"],var.equal=TRUE)
)
```

```
##
## Two Sample t-test
##
## data: dimension_mean[diagnosis == "B"] and dimension_mean[diagnosis == "M"]
## t = 0.30571, df = 567, p-value = 0.7599
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.001016083 0.001390684
## sample estimates:
## mean of x mean of y
## 0.06286739 0.06268009
```

```
#Hotelling's T2 test
#install.packages("Hotelling")
library(Hotelling)
```

```
## Warning: package 'Hotelling' was built under R version 3.5.2
```

```
## Loading required package: corpcor
```

```
## Warning: package 'corpcor' was built under R version 3.5.2
```

```
t2testcan <- hotelling.test(radius_mean + texture_mean + perimeter_mean + area_mean + smoothness_mean + compactness_mean + concavity_mean + points_mean + symmetry_mean + dimension_mean ~ diagnosis, data=breast_cancer)
# Output of the function hotelling.test is given
cat("T2 statistic =",t2testcan$stat[[1]],"\n")
```

```
## T2 statistic = 1220.313
```

```
print(t2testcan)
```

```
## Test stat: 120.09
## Numerator df: 10
## Denominator df: 558
## P-value: 0
```

```
# T2 statistic is located in the first element of the list "stat"
#View(t2testcan)
#View(breast_cancer)

#Levene's tests based on absolute differences around means using t-tests. Standardizing the data set with scale()
matstand <- scale(breast_cancer[,3:10])
head(matstand)
```

```
##      radius_mean texture_mean perimeter_mean area_mean smoothness_mean
## [1,] -0.5128453 -1.60418301 -0.5399006 -0.5421468 0.4578825
## [2,] -1.0009202 -0.07896900 -0.9337442 -0.8766033 0.0369535
## [3,] -0.8760638 -0.57187353 -0.8662517 -0.8004484 0.8062867
## [4,] -0.8079604 -1.37168088 -0.7806514 -0.7674858 1.4248817
## [5,] 0.3015589 -1.41353126 0.2337944 0.1617181 -1.1895712
## [6,] -0.7256686 -0.05804381 -0.7312666 -0.6967299 -0.7750414
##      compactness_mean concavity_mean points_mean
## [1,] -0.6538379 -0.6137661 -0.30717196
## [2,] 0.1961461 -0.3127117 -0.57983238
## [3,] -0.4980044 -0.7318045 -0.62158190
## [4,] 0.1753178 -0.5324814 -0.02471844
## [5,] -0.6627373 -0.6882771 -0.57596668
## [6,] -0.5135309 -0.4258580 -0.89269604
```

```
matben <- matstand[breast_cancer$diagnosis == "B",]
head(matben)
```

```
##      radius_mean texture_mean perimeter_mean area_mean smoothness_mean
## [1,] -0.5128453 -1.60418301 -0.5399006 -0.5421468 0.4578825
## [2,] -1.0009202 -0.07896900 -0.9337442 -0.8766033 0.0369535
## [3,] -0.8760638 -0.57187353 -0.8662517 -0.8004484 0.8062867
## [4,] -0.8079604 -1.37168088 -0.7806514 -0.7674858 1.4248817
## [5,] 0.3015589 -1.41353126 0.2337944 0.1617181 -1.1895712
## [6,] -0.7256686 -0.05804381 -0.7312666 -0.6967299 -0.7750414
##      compactness_mean concavity_mean points_mean
## [1,] -0.6538379 -0.6137661 -0.30717196
## [2,] 0.1961461 -0.3127117 -0.57983238
## [3,] -0.4980044 -0.7318045 -0.62158190
## [4,] 0.1753178 -0.5324814 -0.02471844
## [5,] -0.6627373 -0.6882771 -0.57596668
## [6,] -0.5135309 -0.4258580 -0.89269604
```

```
matmalign <- matstand[breast_cancer$diagnosis == "M",]
vecmedianben <- apply(matben, 2, median)
# in the above 2 represents column. Hence, we are asking for column median
vecmedianben
```

```
##      radius_mean    texture_mean    perimeter_mean    area_mean
##      -0.5468970     -0.4416723     -0.5674737     -0.5583439
## smoothness_mean compactness_mean    concavity_mean    points_mean
##      -0.3981961     -0.5500751     -0.6486382     -0.6566309
```

```
vecmedianmalign <- apply(matmalign, 2, median)
matabsdevben <- abs(matben - matrix(rep(vecmedianben,nrow(matben)),nrow=nrow(matben), byrow=TRUE))

matabsdevmalign <- abs(matmalign - matrix(rep(vecmedianmalign,nrow(matmalign)),nrow=nrow(matmalign), byrow=TRUE))

head(matabsdevmalign)
```

```
##      radius_mean texture_mean perimeter_mean area_mean smoothness_mean
## [1,]  0.9974323   0.53242989   0.9317263  0.9496635   2.14019666
## [2,]  0.9264911   0.05115047   0.9712341  1.1025417   0.44794814
## [3,]  0.6427266   0.82305756   0.5555789  0.7359750   0.07110288
## [4,]  0.7846089   0.55800512   0.8436568  0.8951047   0.41239670
## [5,]  1.0002699   1.31828711   0.9782303  0.9885934   0.10665432
## [6,]  0.5746231   0.88583314   0.4856171  0.5671838   0.42661727
##      compactness_mean concavity_mean points_mean
## [1,]  0.84165269   0.05582051  0.14122676
## [2,]  0.60686094   0.84608833  0.66541513
## [3,]  0.63696730   0.17749666  0.11210518
## [4,]  0.97419643   0.96525570  1.07517890
## [5,]  0.08236646   0.92147737  0.91720079
## [6,]  0.70721548   0.21261968  0.03169871
```

```
matabsdev.all <- rbind(matabsdevben,matabsdevmalign)
matabsdev.all <- data.frame(breast_cancer$diagnosis, matabsdev.all)

t.test(matabsdev.all$radius_mean[breast_cancer$diagnosis == "B"],matabsdev.all$radius_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$radius_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$radius_mean[breast_cancer$diagnosis == "M"]
## t = 0.32562, df = 567, p-value = 0.6276
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.07485419
## sample estimates:
## mean of x mean of y
## 0.5301158 0.5177632
```

```
t.test(matabsdev.all$texture_mean[breast_cancer$diagnosis == "B"],matabsdev.all$texture_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$texture_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$texture_mean[breast_cancer$diagnosis == "M"]
## t = -2.1618, df = 567, p-value = 0.01553
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf -0.02723094
## sample estimates:
## mean of x mean of y
## 0.6364762 0.7509490
```

```
t.test(matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "B"],matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$perimeter_mean[breast_cancer$diagnosis == "M"]
## t = 0.2439, df = 567, p-value = 0.5963
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.07148672
## sample estimates:
## mean of x mean of y
## 0.5125724 0.5033541
```

```
t.test(matabsdev.all$area_mean[breast_cancer$diagnosis == "B"],matabsdev.all$area_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$area_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$area_mean[breast_cancer$diagnosis == "M"]
## t = 0.40112, df = 567, p-value = 0.6558
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.0909786
## sample estimates:
## mean of x mean of y
## 0.4981297 0.4803166
```

```
t.test(matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "B"],matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$smoothness_mean[breast_cancer$diagnosis == "M"]
## t = 1.6742, df = 567, p-value = 0.9527
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.167207
## sample estimates:
## mean of x mean of y
## 0.7680704 0.6837950
```

```
t.test(matabsdev.all$compactness_mean[breast_cancer$diagnosis == "B"],matabsdev.all$compactness_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$compactness_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$compactness_mean[breast_cancer$diagnosis == "M"]
## t = 1.8406, df = 567, p-value = 0.9669
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.1710355
## sample estimates:
## mean of x mean of y
## 0.6249227 0.5346711
```

```
t.test(matabsdev.all$concavity_mean[breast_cancer$diagnosis == "B"],matabsdev.all$concavity_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$concavity_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$concavity_mean[breast_cancer$diagnosis == "M"]
## t = 1.0995, df = 567, p-value = 0.864
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.1302286
## sample estimates:
## mean of x mean of y
## 0.4977532 0.4456302
```

```
t.test(matabsdev.all$points_mean[breast_cancer$diagnosis == "B"],matabsdev.all$points_mean[breast_cancer$diagnosis == "M"], alternative="less",var.equal = TRUE)
```

```
##
## Two Sample t-test
##
## data: matabsdev.all$points_mean[breast_cancer$diagnosis == "B"] and matabsdev.all$points_mean[breast_cancer$diagnosis == "M"]
## t = 0.31387, df = 567, p-value = 0.6231
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##      -Inf 0.07740908
## sample estimates:
## mean of x mean of y
## 0.4434506 0.4310634
```

```
head(matstand)
```

```
##      radius_mean texture_mean perimeter_mean area_mean smoothness_mean
## [1,] -0.5128453 -1.60418301 -0.5399006 -0.5421468 0.4578825
## [2,] -1.0009202 -0.07896900 -0.9337442 -0.8766033 0.0369535
## [3,] -0.8760638 -0.57187353 -0.8662517 -0.8004484 0.8062867
## [4,] -0.8079604 -1.37168088 -0.7806514 -0.7674858 1.4248817
## [5,] 0.3015589 -1.41353126 0.2337944 0.1617181 -1.1895712
## [6,] -0.7256686 -0.05804381 -0.7312666 -0.6967299 -0.7750414
## compactness_mean concavity_mean points_mean
## [1,] -0.6538379 -0.6137661 -0.30717196
## [2,] 0.1961461 -0.3127117 -0.57983238
## [3,] -0.4980044 -0.7318045 -0.62158190
## [4,] 0.1753178 -0.5324814 -0.02471844
## [5,] -0.6627373 -0.6882771 -0.57596668
## [6,] -0.5135309 -0.4258580 -0.89269604
```

```
matstand.all <- data.frame(breast_cancer$diagnosis, matstand)
head(matstand.all)
```

```
## breast_cancer.diagnosis radius_mean texture_mean perimeter_mean
## 1 B -0.5128453 -1.60418301 -0.5399006
## 2 B -1.0009202 -0.07896900 -0.9337442
## 3 B -0.8760638 -0.57187353 -0.8662517
## 4 B -0.8079604 -1.37168088 -0.7806514
## 5 B 0.3015589 -1.41353126 0.2337944
## 6 B -0.7256686 -0.05804381 -0.7312666
## area_mean smoothness_mean compactness_mean concavity_mean points_mean
## 1 -0.5421468 0.4578825 -0.6538379 -0.6137661 -0.30717196
## 2 -0.8766033 0.0369535 0.1961461 -0.3127117 -0.57983238
## 3 -0.8004484 0.8062867 -0.4980044 -0.7318045 -0.62158190
## 4 -0.7674858 1.4248817 0.1753178 -0.5324814 -0.02471844
## 5 0.1617181 -1.1895712 -0.6627373 -0.6882771 -0.57596668
## 6 -0.6967299 -0.7750414 -0.5135309 -0.4258580 -0.89269604
```

```
colnames(matstand.all) <- colnames(breast_cancer[2:10])
t2testcan <- hotelling.test(radius_mean + texture_mean + perimeter_mean + area_mean + smoothness_mean + compactness_mean + concavity_mean + points_mean + symmetry_mean + dimension_mean ~ diagnosis, data=breast_cancer)
cat("T2 statistic =",t2testcan$stat[[1]],"\n")
```

```
## T2 statistic = 1220.313
```

```
print(t2testcan)
```

```
## Test stat: 120.09
## Numerator df: 10
## Denominator df: 558
## P-value: 0
```

```
# In the above we standardized using scale function
head(matabsdev.all)
```

```
## breast_cancer.diagnosis radius_mean texture_mean perimeter_mean
## 1 B 0.03405174 1.1625107 0.02757317
## 2 B 0.45402322 0.3627033 0.36627050
## 3 B 0.32916684 0.1302012 0.29877796
## 4 B 0.26106335 0.9300085 0.21317766
## 5 B 0.84845589 0.9718589 0.80126817
## 6 B 0.17877164 0.3836285 0.16379288
## area_mean smoothness_mean compactness_mean concavity_mean points_mean
## 1 0.01619713 0.8560787 0.10376281 0.03487214 0.34945891
## 2 0.31825946 0.4351496 0.74622121 0.33592655 0.07679849
## 3 0.24210452 1.2044828 0.05207075 0.08316628 0.03504898
## 4 0.20914193 1.8230778 0.72539291 0.11615683 0.63191243
## 5 0.72006202 0.7913750 0.11266217 0.03963883 0.08066419
## 6 0.13838603 0.3768453 0.03654420 0.22278026 0.23606517
```

```
#install.packages("car")
library(car)
```

```
## Warning: package 'car' was built under R version 3.5.2
```

```
## Loading required package: carData
```

```
#leveneTest() produces a two-sided test
# Levene test is used to verify Homoscedasticity. It tests if the variance of two samples are # equal. Levene's test is an inferential statistic used to assess the equality of variances for a #variable calculated for two or more groups.[1] Some common statistical procedures assume that #variances of the populations from which different samples are drawn are equal. Levene's test #assesses this assumption.
leveneTest(radius_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group 1  90.477 < 2.2e-16 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(texture_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value Pr(>F)
## group 1   0.684 0.4086
##      567
```

```
leveneTest(perimeter_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1  91.237 < 2.2e-16 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(area_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1 170.21 < 2.2e-16 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(smoothness_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value Pr(>F)
## group  1  0.8377 0.3604
##      567
```

```
leveneTest(compactness_mean~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1 39.892 5.428e-10 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(concavity_mean~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1 70.484 3.723e-16 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(points_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1 94.906 < 2.2e-16 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
leveneTest(symmetry_mean ~ diagnosis, data=breast_cancer)
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value Pr(>F)
## group  1  2.036 0.1542
##      567
```

```
leveneTest(dimension_mean ~ diagnosis, data=breast_cancer)
```



```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value Pr(>F)
## group 1    6.113 0.01371 *
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#PCA
```

```
dim(breast_cancer)
```

```
## [1] 569 32
```

```
attach(breast_cancer)
head(breast_cancer)
```

```
##      id diagnosis radius_mean texture_mean perimeter_mean area_mean
## 1 87139402      B      12.32      12.39      78.85      464.1
## 2 8910251      B      10.60      18.95      69.28      346.4
## 3 905520      B      11.04      16.83      70.92      373.2
## 4 868871      B      11.28      13.39      73.00      384.8
## 5 9012568      B      15.19      13.21      97.65      711.8
## 6 906539      B      11.57      19.04      74.20      409.7
## smoothness_mean compactness_mean concavity_mean points_mean
## 1      0.10280      0.06981      0.03987      0.03700
## 2      0.09688      0.11470      0.06387      0.02642
## 3      0.10770      0.07804      0.03046      0.02480
## 4      0.11640      0.11360      0.04635      0.04796
## 5      0.07963      0.06934      0.03393      0.02657
## 6      0.08546      0.07722      0.05485      0.01428
## symmetry_mean dimension_mean radius_se texture_se perimeter_se area_se
## 1      0.1959      0.05955      0.2360      0.6656      1.670      17.43
## 2      0.1922      0.06491      0.4505      1.1970      3.430      27.10
## 3      0.1714      0.06340      0.1967      1.3870      1.342      13.54
## 4      0.1771      0.06072      0.3384      1.3430      1.851      26.33
## 5      0.1721      0.05544      0.1783      0.4125      1.338      17.72
## 6      0.2031      0.06267      0.2864      1.4400      2.206      20.30
## smoothness_se compactness_se concavity_se points_se symmetry_se
## 1      0.008045      0.011800      0.01683      0.012410      0.01924
## 2      0.007470      0.035810      0.03354      0.013650      0.03504
## 3      0.005158      0.009355      0.01056      0.007483      0.01718
## 4      0.011270      0.034980      0.02187      0.019650      0.01580
## 5      0.005012      0.014850      0.01551      0.009155      0.01647
## 6      0.007278      0.020470      0.04447      0.008799      0.01868
## dimension_se radius_worst texture_worst perimeter_worst area_worst
## 1      0.002248      13.50      15.64      86.97      549.1
## 2      0.003318      11.88      22.94      78.28      424.8
## 3      0.002198      12.41      26.44      79.93      471.4
## 4      0.003442      11.92      15.77      76.53      434.0
## 5      0.001767      16.20      15.73      104.50      819.1
## 6      0.003339      13.07      26.98      86.43      520.5
## smoothness_worst compactness_worst concavity_worst points_worst
## 1      0.1385      0.1266      0.12420      0.09391
## 2      0.1213      0.2515      0.19160      0.07926
## 3      0.1369      0.1482      0.10670      0.07431
## 4      0.1367      0.1822      0.08669      0.08611
## 5      0.1126      0.1737      0.13620      0.08178
## 6      0.1249      0.1937      0.25600      0.06664
## symmetry_worst dimension_worst
## 1      0.2827      0.06771
## 2      0.2940      0.07587
## 3      0.2998      0.07881
## 4      0.2102      0.06784
## 5      0.2487      0.06766
## 6      0.3035      0.08284
```

```
#Get the Correlations between the measurements
cor(breast_cancer[,-2])
```

##		id	radius_mean	texture_mean	perimeter_mean
##	id	1.0000000000	0.074626470	0.099769891	0.073159412
##	radius_mean	0.0746264697	1.0000000000	0.323781891	0.997855281
##	texture_mean	0.0997698912	0.323781891	1.0000000000	0.329533059
##	perimeter_mean	0.0731594119	0.997855281	0.329533059	1.0000000000
##	area_mean	0.0968928233	0.987357170	0.321085696	0.986506804
##	smoothness_mean	-0.0129681975	0.170581187	-0.023388516	0.207278164
##	compactness_mean	0.0000957011	0.506123578	0.236702222	0.556936211
##	concavity_mean	0.0500799532	0.676763550	0.302417828	0.716135650
##	points_mean	0.0441580956	0.822528522	0.293464051	0.850977041
##	symmetry_mean	-0.0221140609	0.147741242	0.071400980	0.183027212
##	dimension_mean	-0.0525114476	-0.311630826	-0.076437183	-0.261476908
##	radius_se	0.1430475814	0.679090388	0.275868676	0.691765014
##	texture_se	-0.0075261904	-0.097317443	0.386357623	-0.086761078
##	perimeter_se	0.1373310660	0.674171616	0.281673115	0.693134890
##	area_se	0.1777419152	0.735863663	0.259844987	0.744982694
##	smoothness_se	0.0967805739	-0.222600125	0.006613777	-0.202694026
##	compactness_se	0.0339609721	0.205999980	0.191974611	0.250743681
##	concavity_se	0.0552393174	0.194203623	0.143293077	0.228082345
##	points_se	0.0787680711	0.376168956	0.163851025	0.407216916
##	symmetry_se	-0.0173062948	-0.104320881	0.009127168	-0.081629327
##	dimension_se	0.0257253243	-0.042641269	0.054457520	-0.005523391
##	radius_worst	0.0824053373	0.969538973	0.352572947	0.969476363
##	texture_worst	0.0647195454	0.297007644	0.912044589	0.303038372
##	perimeter_worst	0.0799858731	0.965136514	0.358039575	0.970386887
##	area_worst	0.1071865233	0.941082460	0.343545947	0.941549808
##	smoothness_worst	0.0103380343	0.119616140	0.077503359	0.150549404
##	compactness_worst	-0.0029680998	0.413462823	0.277829592	0.455774228
##	concavity_worst	0.0232027439	0.526911462	0.301025224	0.563879263
##	points_worst	0.0351735794	0.744214198	0.295315843	0.771240789
##	symmetry_worst	-0.0442242529	0.163953335	0.105007910	0.189115040
##	dimension_worst	-0.0298656360	0.007065886	0.119205351	0.051018530
##		area_mean	smoothness_mean	compactness_mean	
##	id	0.096892823	-0.01296820	0.0000957011	
##	radius_mean	0.987357170	0.17058119	0.5061235775	
##	texture_mean	0.321085696	-0.02338852	0.2367022221	
##	perimeter_mean	0.986506804	0.20727816	0.5569362109	
##	area_mean	1.0000000000	0.17702838	0.4985016822	
##	smoothness_mean	0.177028377	1.0000000000	0.6591232152	
##	compactness_mean	0.498501682	0.65912322	1.0000000000	
##	concavity_mean	0.685982829	0.52198377	0.8831206702	
##	points_mean	0.823268869	0.55369517	0.8311350431	
##	symmetry_mean	0.151293079	0.55777479	0.6026410484	
##	dimension_mean	-0.283109812	0.58479200	0.5653686634	
##	radius_se	0.732562227	0.30146710	0.4974734461	
##	texture_se	-0.066280214	0.06840645	0.0462048307	
##	perimeter_se	0.726628328	0.29609193	0.5489052646	
##	area_se	0.800085921	0.24655243	0.4556528520	
##	smoothness_se	-0.166776667	0.33237544	0.1352992677	
##	compactness_se	0.212582551	0.31894330	0.7387217897	
##	concavity_se	0.207660060	0.24839568	0.5705168715	
##	points_se	0.372320282	0.38067569	0.6422618510	
##	symmetry_se	-0.072496588	0.20077438	0.2299765908	
##	dimension_se	-0.019886963	0.28360670	0.5073181269	
##	radius_worst	0.962746086	0.21312014	0.5353153982	
##	texture_worst	0.287488627	0.03607180	0.2481328333	
##	perimeter_worst	0.959119574	0.23885263	0.5902104277	
##	area_worst	0.959213326	0.20671836	0.5096038056	
##	smoothness_worst	0.123522939	0.80532420	0.5655411664	
##	compactness_worst	0.390410309	0.47246844	0.8658090398	
##	concavity_worst	0.512605920	0.43492571	0.8162752498	
##	points_worst	0.722016626	0.50305335	0.8155732236	
##	symmetry_worst	0.143569914	0.39430948	0.5102234299	
##	dimension_worst	0.003737597	0.49931637	0.6873823228	
##		concavity_mean	points_mean	symmetry_mean	dimension_mean
##	id	0.05007995	0.04415810	-0.02211406	-0.0525114476
##	radius_mean	0.67676355	0.82252852	0.14774124	-0.3116308263
##	texture_mean	0.30241783	0.29346405	0.07140098	-0.0764371834
##	perimeter_mean	0.71613565	0.85097704	0.18302721	-0.2614769081
##	area_mean	0.68598283	0.82326887	0.15129308	-0.2831098117
##	smoothness_mean	0.52198377	0.55369517	0.55777479	0.5847920019
##	compactness_mean	0.88312067	0.83113504	0.60264105	0.5653686634

## concavity_mean	1.00000000	0.92139103	0.50066662	0.3367833594
## points_mean	0.92139103	1.00000000	0.46249739	0.1669173832
## symmetry_mean	0.50066662	0.46249739	1.00000000	0.4799213301
## dimension_mean	0.33678336	0.16691738	0.47992133	1.0000000000
## radius_se	0.63192482	0.69804983	0.30337926	0.0001109951
## texture_se	0.07621835	0.02147958	0.12805293	0.1641739659
## perimeter_se	0.66039079	0.71064987	0.31389276	0.0398299316
## area_se	0.61742681	0.69029854	0.22397022	-0.0901702475
## smoothness_se	0.09856375	0.02765331	0.18732117	0.4019644254
## compactness_se	0.67027882	0.49042425	0.42165915	0.5598366906
## concavity_se	0.69127021	0.43916707	0.34262702	0.4466303217
## points_se	0.68325992	0.61563413	0.39329787	0.3411980444
## symmetry_se	0.17800921	0.09535079	0.44913654	0.3450073971
## dimension_se	0.44930075	0.25758375	0.33178615	0.6881315775
## radius_worst	0.68823641	0.83031763	0.18572775	-0.2536914949
## texture_worst	0.29987889	0.29275171	0.09065069	-0.0512692020
## perimeter_worst	0.72956492	0.85592313	0.21916856	-0.2051512113
## area_worst	0.67598723	0.80962962	0.17719338	-0.2318544512
## smoothness_worst	0.44882204	0.45275305	0.42667503	0.5049420754
## compactness_worst	0.75496802	0.66745368	0.47320001	0.4587981567
## concavity_worst	0.88410264	0.75239950	0.43372101	0.3462338763
## points_worst	0.86132303	0.91015531	0.43029661	0.1753254492
## symmetry_worst	0.40946413	0.37574415	0.69982580	0.3340186839
## dimension_worst	0.51492989	0.36866113	0.43841350	0.7672967792
##	radius_se	texture_se	perimeter_se	area_se
## id	0.1430475814	-0.00752619	0.13733107	0.17774192
## radius_mean	0.6790903880	-0.09731744	0.67417162	0.73586366
## texture_mean	0.2758686762	0.38635762	0.28167311	0.25984499
## perimeter_mean	0.6917650135	-0.08676108	0.69313489	0.74498269
## area_mean	0.7325622270	-0.06628021	0.72662833	0.80008592
## smoothness_mean	0.3014670983	0.06840645	0.29609193	0.24655243
## compactness_mean	0.4974734461	0.04620483	0.54890526	0.45565285
## concavity_mean	0.6319248221	0.07621835	0.66039079	0.61742681
## points_mean	0.6980498336	0.02147958	0.71064987	0.69029854
## symmetry_mean	0.3033792632	0.12805293	0.31389276	0.22397022
## dimension_mean	0.0001109951	0.16417397	0.03982993	-0.09017025
## radius_se	1.0000000000	0.21324734	0.97279368	0.95183011
## texture_se	0.2132473373	1.00000000	0.22317073	0.11156725
## perimeter_se	0.9727936770	0.22317073	1.00000000	0.93765541
## area_se	0.9518301121	0.11156725	0.93765541	1.00000000
## smoothness_se	0.1645142198	0.39724285	0.15107533	0.07515034
## compactness_se	0.3560645755	0.23169970	0.41632237	0.28484006
## concavity_se	0.3323575376	0.19499846	0.36248158	0.27089473
## points_se	0.5133464414	0.23028340	0.55626408	0.41572957
## symmetry_se	0.2405673625	0.41162068	0.26648709	0.13410898
## dimension_se	0.2277535327	0.27972275	0.24414277	0.12707090
## radius_worst	0.7150651951	-0.11169031	0.69720059	0.75737319
## texture_worst	0.1947985568	0.40900277	0.20037085	0.19649665
## perimeter_worst	0.7196838037	-0.10224192	0.72103131	0.76121264
## area_worst	0.7515484761	-0.08319499	0.73071297	0.81140796
## smoothness_worst	0.1419185529	-0.07365766	0.13005439	0.12538943
## compactness_worst	0.2871031656	-0.09243935	0.34191945	0.28325654
## concavity_worst	0.3805846346	-0.06895622	0.41889882	0.38510014
## points_worst	0.5310623278	-0.11963752	0.55489723	0.53816631
## symmetry_worst	0.0945428304	-0.12821476	0.10993043	0.07412629
## dimension_worst	0.0495594325	-0.04565457	0.08543257	0.01753930
##	smoothness_se	compactness_se	concavity_se	points_se
## id	0.096780574	0.03396097	0.05523932	0.07876807
## radius_mean	-0.222600125	0.20599998	0.19420362	0.37616896
## texture_mean	0.006613777	0.19197461	0.14329308	0.16385103
## perimeter_mean	-0.202694026	0.25074368	0.22808235	0.40721692
## area_mean	-0.166776667	0.21258255	0.20766006	0.37232028
## smoothness_mean	0.332375443	0.31894330	0.24839568	0.38067569
## compactness_mean	0.135299268	0.73872179	0.57051687	0.64226185
## concavity_mean	0.098563746	0.67027882	0.69127021	0.68325992
## points_mean	0.027653308	0.49042425	0.43916707	0.61563413
## symmetry_mean	0.187321165	0.42165915	0.34262702	0.39329787
## dimension_mean	0.401964425	0.55983669	0.44663032	0.34119804
## radius_se	0.164514220	0.35606458	0.33235754	0.51334644
## texture_se	0.397242853	0.23169970	0.19499846	0.23028340
## perimeter_se	0.151075331	0.41632237	0.36248158	0.55626408
## area_se	0.075150338	0.28484006	0.27089473	0.41572957
## smoothness se	1.000000000	0.33669608	0.26868476	0.32842950

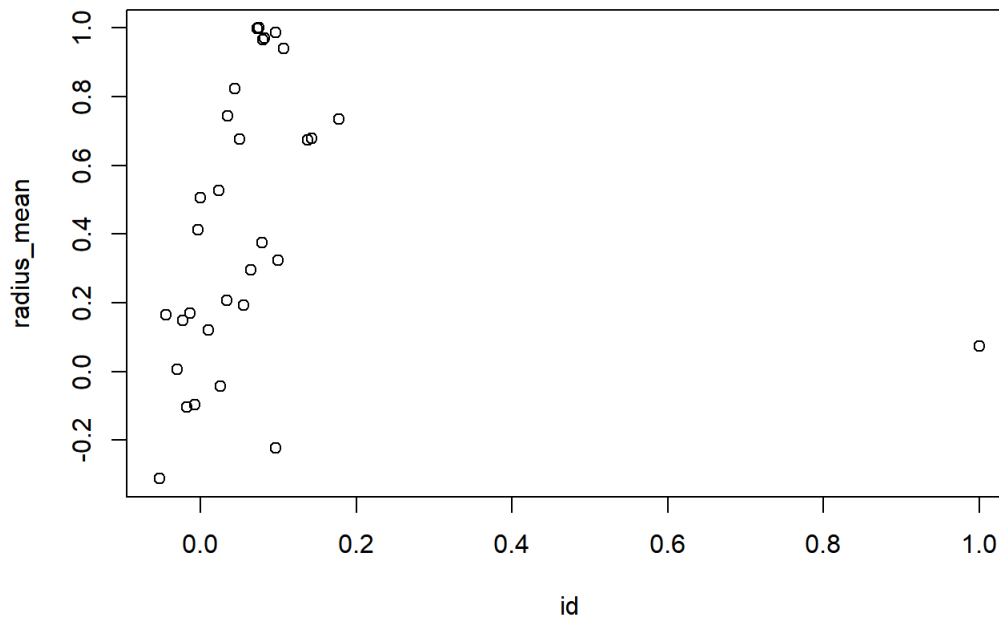
## compactness_se	0.336696081	1.00000000	0.80126834	0.74408267
## concavity_se	0.268684760	0.80126834	1.00000000	0.77180399
## points_se	0.328429499	0.74408267	0.77180399	1.00000000
## symmetry_se	0.413506125	0.39471283	0.30942858	0.31278022
## dimension_se	0.427374207	0.80326882	0.72737218	0.61104414
## radius_worst	-0.230690710	0.20460717	0.18690352	0.35812667
## texture_worst	-0.074742965	0.14300258	0.10024098	0.08674121
## perimeter_worst	-0.217303755	0.26051584	0.22668043	0.39499925
## area_worst	-0.182195478	0.19937133	0.18835265	0.34227116
## smoothness_worst	0.314457456	0.22739423	0.16848132	0.21535060
## compactness_worst	-0.055558139	0.67878035	0.48485780	0.45288838
## concavity_worst	-0.058298387	0.63914670	0.66256413	0.54959238
## points_worst	-0.102006796	0.48320833	0.44047226	0.60244961
## symmetry_worst	-0.107342098	0.27787843	0.19778782	0.14311567
## dimension_worst	0.101480315	0.59097276	0.43932927	0.31065455
##	symmetry_se	dimension_se	radius_worst	texture_worst
## id	-0.017306295	0.025725324	0.08240534	0.064719545
## radius_mean	-0.104320881	-0.042641269	0.96953897	0.297007644
## texture_mean	0.009127168	0.054457520	0.35257295	0.912044589
## perimeter_mean	-0.081629327	-0.005523391	0.96947636	0.303038372
## area_mean	-0.072496588	-0.019886963	0.96274609	0.287488627
## smoothness_mean	0.200774376	0.283606699	0.21312014	0.036071799
## compactness_mean	0.229976591	0.507318127	0.53531540	0.248132833
## concavity_mean	0.178009208	0.449300749	0.68823641	0.299878889
## points_mean	0.095350787	0.257583746	0.83031763	0.292751713
## symmetry_mean	0.449136542	0.331786146	0.18572775	0.090650688
## dimension_mean	0.345007397	0.688131577	-0.25369149	-0.051269202
## radius_se	0.240567362	0.227753533	0.71506520	0.194798557
## texture_se	0.411620680	0.279722748	-0.11169031	0.409002766
## perimeter_se	0.266487092	0.244142773	0.69720059	0.200370854
## area_se	0.134108980	0.127070903	0.75737319	0.196496649
## smoothness_se	0.413506125	0.427374207	-0.23069071	-0.074742965
## compactness_se	0.394712835	0.803268818	0.20460717	0.143002583
## concavity_se	0.309428578	0.727372184	0.18690352	0.100240984
## points_se	0.312780223	0.611044139	0.35812667	0.086741210
## symmetry_se	1.000000000	0.369078083	-0.12812077	-0.077473420
## dimension_se	0.369078083	1.000000000	-0.03748762	-0.003195029
## radius_worst	-0.128120769	-0.037487618	1.00000000	0.359920754
## texture_worst	-0.077473420	-0.003195029	0.35992075	1.000000000
## perimeter_worst	-0.103753044	-0.001000398	0.99370792	0.365098245
## area_worst	-0.110342743	-0.022736147	0.98401456	0.345842283
## smoothness_worst	-0.012661800	0.170568316	0.21657443	0.225429415
## compactness_worst	0.060254879	0.390158842	0.47582004	0.360832339
## concavity_worst	0.037119049	0.379974661	0.57397471	0.368365607
## points_worst	-0.030413396	0.215204013	0.78742385	0.359754610
## symmetry_worst	0.389402485	0.111093956	0.24352920	0.233027461
## dimension_worst	0.078079476	0.591328066	0.09349198	0.219122425
##	perimeter_worst	area_worst	smoothness_worst	
## id	0.079985873	0.10718652	0.01033803	
## radius_mean	0.965136514	0.94108246	0.11961614	
## texture_mean	0.358039575	0.34354595	0.07750336	
## perimeter_mean	0.970386887	0.94154981	0.15054940	
## area_mean	0.959119574	0.95921333	0.12352294	
## smoothness_mean	0.238852626	0.20671836	0.80532420	
## compactness_mean	0.590210428	0.50960381	0.56554117	
## concavity_mean	0.729564917	0.67598723	0.44882204	
## points_mean	0.855923128	0.80962962	0.45275305	
## symmetry_mean	0.219168559	0.17719338	0.42667503	
## dimension_mean	-0.205151211	-0.23185445	0.50494208	
## radius_se	0.719683804	0.75154848	0.14191855	
## texture_se	-0.102241922	-0.08319499	-0.07365766	
## perimeter_se	0.721031310	0.73071297	0.13005439	
## area_se	0.761212636	0.81140796	0.12538943	
## smoothness_se	-0.217303755	-0.18219548	0.31445746	
## compactness_se	0.260515840	0.19937133	0.22739423	
## concavity_se	0.226680426	0.18835265	0.16848132	
## points_se	0.394999252	0.34227116	0.21535060	
## symmetry_se	-0.103753044	-0.11034274	-0.01266180	
## dimension_se	-0.001000398	-0.02273615	0.17056832	
## radius_worst	0.993707916	0.98401456	0.21657443	
## texture_worst	0.365098245	0.34584228	0.22542941	
## perimeter_worst	1.000000000	0.97757809	0.23677460	
## area_worst	0.977578091	1.00000000	0.20914533	

```

## area_worst      0.277570091 1.00000000 0.20914533
## smoothness_worst 0.236774604 0.20914533 1.00000000
## compactness_worst 0.529407690 0.43829628 0.56818652
## concavity_worst 0.618344080 0.54333053 0.51852329
## points_worst 0.816322102 0.74741880 0.54769090
## symmetry_worst 0.269492769 0.20914551 0.49383833
## dimension_worst 0.138956862 0.07964703 0.61762419
## compactness_worst concavity_worst points_worst
## id -0.00296810 0.02320274 0.03517358
## radius_mean 0.41346282 0.52691146 0.74421420
## texture_mean 0.27782959 0.30102522 0.29531584
## perimeter_mean 0.45577423 0.56387926 0.77124079
## area_mean 0.39041031 0.51260592 0.72201663
## smoothness_mean 0.47246844 0.43492571 0.50305335
## compactness_mean 0.86580904 0.81627525 0.81557322
## concavity_mean 0.75496802 0.88410264 0.86132303
## points_mean 0.66745368 0.75239950 0.91015531
## symmetry_mean 0.47320001 0.43372101 0.43029661
## dimension_mean 0.45879816 0.34623388 0.17532545
## radius_se 0.28710317 0.38058463 0.53106233
## texture_se -0.09243935 -0.06895622 -0.11963752
## perimeter_se 0.34191945 0.41889882 0.55489723
## area_se 0.28325654 0.38510014 0.53816631
## smoothness_se -0.05555814 -0.05829839 -0.10200680
## compactness_se 0.67878035 0.63914670 0.48320833
## concavity_se 0.48485780 0.66256413 0.44047226
## points_se 0.45288838 0.54959238 0.60244961
## symmetry_se 0.06025488 0.03711905 -0.03041340
## dimension_se 0.39015884 0.37997466 0.21520401
## radius_worst 0.47582004 0.57397471 0.78742385
## texture_worst 0.36083234 0.36836561 0.35975461
## perimeter_worst 0.52940769 0.61834408 0.81632210
## area_worst 0.43829628 0.54333053 0.74741880
## smoothness_worst 0.56818652 0.51852329 0.54769090
## compactness_worst 1.00000000 0.89226090 0.80108036
## concavity_worst 0.89226090 1.00000000 0.85543386
## points_worst 0.80108036 0.85543386 1.00000000
## symmetry_worst 0.61444050 0.53251973 0.50252849
## dimension_worst 0.81045486 0.68651092 0.51111415
## symmetry_worst dimension_worst
## id -0.04422425 -0.029865636
## radius_mean 0.16395333 0.007065886
## texture_mean 0.10500791 0.119205351
## perimeter_mean 0.18911504 0.051018530
## area_mean 0.14356991 0.003737597
## smoothness_mean 0.39430948 0.499316369
## compactness_mean 0.51022343 0.687382323
## concavity_mean 0.40946413 0.514929891
## points_mean 0.37574415 0.368661134
## symmetry_mean 0.69982580 0.438413498
## dimension_mean 0.33401868 0.767296779
## radius_se 0.09454283 0.049559432
## texture_se -0.12821476 -0.045654569
## perimeter_se 0.10993043 0.085432572
## area_se 0.07412629 0.017539295
## smoothness_se -0.10734210 0.101480315
## compactness_se 0.27787843 0.590972763
## concavity_se 0.19778782 0.439329269
## points_se 0.14311567 0.310654551
## symmetry_se 0.38940248 0.078079476
## dimension_se 0.11109396 0.591328066
## radius_worst 0.24352920 0.093491979
## texture_worst 0.23302746 0.219122425
## perimeter_worst 0.26949277 0.138956862
## area_worst 0.20914551 0.079647034
## smoothness_worst 0.49383833 0.617624192
## compactness_worst 0.61444050 0.810454856
## concavity_worst 0.53251973 0.686510921
## points_worst 0.50252849 0.511114146
## symmetry_worst 1.00000000 0.537848206
## dimension_worst 0.53784821 1.000000000

```

```
c <- (cor(breast_cancer[-2]))
plot(c)
```



```
# Using prcomp to compute the principal components (eigenvalues and eigenvectors). With scale=TRUE, variable
means are set to zero, and variances set to one
breast_cancer_pca <- prcomp(breast_cancer[, -2], scale=TRUE)
breast_cancer_pca
```

```
## Standard deviations (1, ..., p=31):
## [1] 3.64527878 2.38679814 1.68386313 1.40760690 1.28406203 1.11115827
## [7] 0.98907696 0.81960537 0.67881693 0.63492763 0.59089337 0.54211662
## [13] 0.51102537 0.49125372 0.39619900 0.30680373 0.28250655 0.24299439
## [19] 0.22932770 0.22163467 0.17626907 0.17303527 0.16562163 0.15572098
## [25] 0.13431069 0.12441756 0.09039745 0.08305482 0.03986650 0.02735646
## [31] 0.01153431
##
## Rotation (n x k) = (31 x 31):
##
## id PC1 PC2 PC3 PC4
## radius_mean -0.02291216 0.034068491 0.096938436 -0.026598045
## texture_mean -0.21891302 0.233271401 -0.011393786 0.042187950
## perimeter_mean -0.10384388 0.060044199 0.066892342 -0.602954308
## area_mean -0.22753491 0.214589002 -0.012124791 0.042752797
## smoothness_mean -0.22104577 0.230668816 0.026293150 0.054114724
## compactness_mean -0.14241471 -0.186422211 -0.103182400 0.158098177
## concavity_mean -0.23906730 -0.152454726 -0.074768623 0.031818117
## points_mean -0.25828025 -0.060541625 0.001758736 0.019497124
## symmetry_mean -0.26073811 0.034167392 -0.027579607 0.065785353
## dimension_mean -0.13797774 -0.190684979 -0.040962032 0.067502543
## radius_se -0.06414779 -0.366531055 -0.020817875 0.047957856
## texture_se -0.20611747 0.105935702 0.266917221 0.099114446
## perimeter_se -0.01741339 -0.089547789 0.371439885 -0.356497230
## area_se -0.21144652 0.089807043 0.264925682 0.090293055
## smoothness_se -0.20307642 0.152771289 0.215790250 0.108568705
## compactness_se -0.01467821 -0.203189876 0.311787845 0.044368664
## concavity_se -0.17028840 -0.232503362 0.154557465 -0.026425360
## points_se -0.15354367 -0.196846081 0.176560052 0.002248291
## symmetry_se -0.18340675 -0.129965181 0.223850479 0.075252232
## dimension_se -0.04241552 -0.183558627 0.285265066 0.046936126
## radius_worst -0.10249607 -0.279584139 0.211893354 0.016212450
## texture_worst -0.22800935 0.219296044 -0.049406340 0.015659705
## perimeter_worst -0.10451545 0.045501223 -0.039828934 -0.633119655
## area_worst -0.23663734 0.199295985 -0.050431945 0.014068572
## smoothness_worst -0.22493214 0.218985461 -0.013188891 0.025970672
## compactness_worst -0.12782441 -0.172562959 -0.255328751 0.014523359
```

## smoothness_worst	-0.12702111	-0.17200299	-0.20002071	-0.01102000
## compactness_worst	-0.20988456	-0.144253637	-0.234513609	-0.092562168
## concavity_worst	-0.22860218	-0.098526524	-0.172024941	-0.074807188
## points_worst	-0.25074620	0.007534367	-0.170480673	0.005305980
## symmetry_worst	-0.12267993	-0.142619436	-0.270515902	-0.037129466
## dimension_worst	-0.13156024	-0.275702077	-0.229474476	-0.078971489
##	PC5	PC6	PC7	PC8
## id	0.011327587	-0.316733438	0.9071156324	-0.096362415
## radius_mean	-0.038129861	0.029588521	-0.0422987777	-0.116427419
## texture_mean	0.049091450	-0.031394323	0.0149935618	0.001875482
## perimeter_mean	-0.037715592	0.028394008	-0.0435888242	-0.106272097
## area_mean	-0.010562229	0.006113155	-0.0289256668	-0.047414568
## smoothness_mean	0.365750055	-0.262508993	-0.1403403617	-0.123541189
## compactness_mean	-0.011786637	-0.004903894	-0.0453031106	0.043145968
## concavity_mean	-0.086512506	-0.002356338	-0.0325530646	-0.102436021
## points_mean	0.043667412	-0.034509273	-0.0814216298	-0.136923237
## symmetry_mean	0.305378893	0.335082168	0.1182592361	-0.098874531
## dimension_mean	0.044767906	-0.112784169	-0.0410588768	0.306499872
## radius_se	0.154254367	-0.023261199	0.0167882718	0.307415709
## texture_se	0.190001500	0.022856912	-0.1902676469	-0.052632477
## perimeter_se	0.120703357	0.003820151	0.0195081762	0.311265679
## area_se	0.127765023	-0.051958835	0.0565606078	0.334287959
## smoothness_se	0.232745603	-0.330867850	-0.0678348099	-0.260833914
## compactness_se	-0.280298048	0.066788120	0.0222220211	0.021001944
## concavity_se	-0.354164595	0.049699104	0.0336810725	-0.219193299
## points_se	-0.195758558	-0.023197526	-0.0378517870	-0.370217167
## symmetry_se	0.251331178	0.477530515	0.1184032606	-0.084854768
## dimension_se	-0.263395188	-0.048462373	-0.0157602244	0.194418818
## radius_worst	0.004280034	0.004521737	-0.0166458140	-0.007508307
## texture_worst	0.092551860	-0.045174516	-0.0094601240	0.006617640
## perimeter_worst	-0.007599144	0.012921166	-0.0145260986	0.002162488
## area_worst	0.027413595	-0.024033338	-0.0007372602	0.066173186
## smoothness_worst	0.325860028	-0.365048687	-0.0670682168	-0.116496117
## compactness_worst	-0.121503371	0.034042714	0.0507556727	0.136509363
## concavity_worst	-0.188280510	0.017962040	0.0352007117	-0.067085744
## points_worst	-0.043123573	-0.029549100	-0.0207238959	-0.166500918
## symmetry_worst	0.244245936	0.451404312	0.2340143294	-0.041439633
## dimension_worst	-0.093699078	-0.092479698	0.0347167538	0.372034479
##	PC9	PC10	PC11	PC12
## id	0.149115642	-0.16926751	0.058188997	-0.006721252
## radius_mean	-0.046270835	-0.22402704	-0.079466081	-0.042213788
## texture_mean	-0.088727168	0.11945674	-0.253258091	0.304032359
## perimeter_mean	-0.036230738	-0.22634517	-0.069865929	-0.017573055
## area_mean	-0.080649856	-0.18600385	-0.062795372	-0.110760120
## smoothness_mean	0.278996404	-0.06133822	0.084661549	0.135321954
## compactness_mean	0.099214048	-0.19518602	0.005172841	0.307036205
## concavity_mean	0.075750464	0.03395563	0.134664686	-0.124553100
## points_mean	0.116569072	-0.14261678	0.006124860	0.071564686
## symmetry_mean	0.315150303	0.13561452	-0.574417320	-0.161058144
## dimension_mean	0.130639482	-0.15848117	-0.066456112	0.037318709
## radius_se	0.026200456	0.26504403	0.025847282	0.027030250
## texture_se	0.372989606	-0.31521084	0.323158815	-0.348396233
## perimeter_se	0.052860114	0.23789288	0.094867442	0.168501485
## area_se	-0.030627892	0.24966405	0.071991560	-0.050731496
## smoothness_se	-0.580789293	-0.01015980	-0.179568831	-0.081753374
## compactness_se	-0.148593714	-0.11518343	-0.038615749	0.206959272
## concavity_se	0.034715098	0.36592141	0.113536362	-0.348342358
## points_se	0.189022962	0.21518752	-0.094066850	0.342855186
## symmetry_se	-0.292785738	-0.22049558	0.328314881	0.185998712
## dimension_se	-0.060203202	-0.22637997	-0.353844543	-0.250428852
## radius_worst	-0.070224590	-0.09981025	-0.073013014	-0.105030701
## texture_worst	-0.008571809	0.10669296	-0.038561250	-0.012490348
## perimeter_worst	-0.058854223	-0.09821693	-0.045750979	-0.051125158
## area_worst	-0.097034650	-0.06179787	-0.068822329	-0.184460981
## smoothness_worst	-0.173257498	0.16912753	0.109278029	-0.142996001
## compactness_worst	-0.111218083	-0.06445290	0.175401648	0.196805544
## concavity_worst	-0.035467377	0.19661986	0.295581609	-0.184959562
## points_worst	0.052322473	0.05121611	0.075496752	0.117518361
## symmetry_worst	-0.188266324	0.10308901	0.019223451	-0.157210098
## dimension_worst	-0.087222442	-0.11291399	-0.007071634	-0.118625115
##	PC13	PC14	PC15	PC16
## id	-0.004841084	-0.006500099	0.006885943	-0.002753492
## radius_mean	0.050603927	-0.012496988	-0.059054553	0.050789156

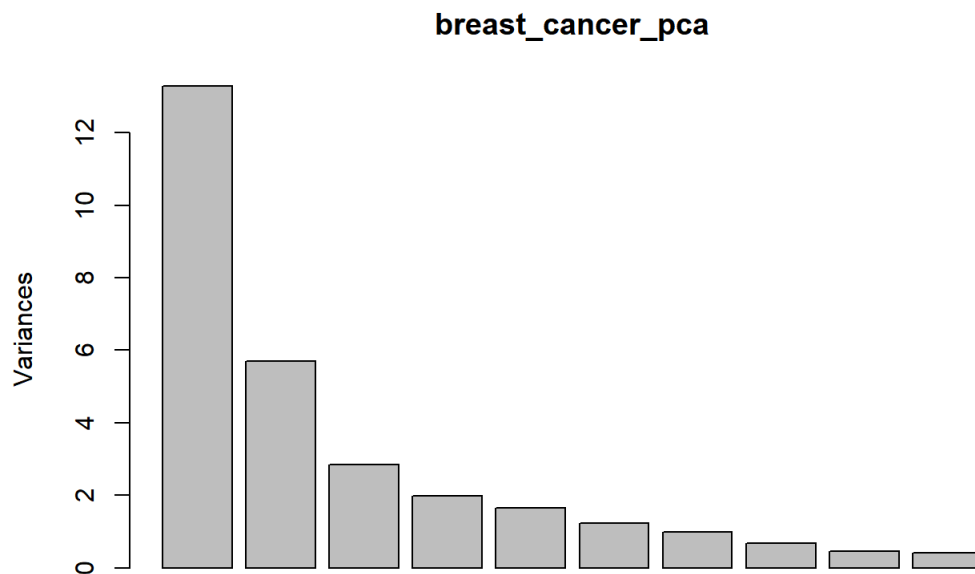
## texture_mean	0.256273666	-0.201876125	0.020701124	0.108089530
## perimeter_mean	0.038470392	-0.044684430	-0.048019221	0.039590476
## area_mean	0.065047550	-0.067879244	-0.010152279	-0.014636050
## smoothness_mean	0.315872261	-0.046461624	-0.444044654	0.117493291
## compactness_mean	-0.104264618	-0.230005458	-0.007661166	-0.230759682
## concavity_mean	0.065723393	-0.387349680	0.189733740	0.128386008
## points_mean	0.042253113	-0.132637847	0.245219266	0.217299938
## symmetry_mean	-0.288054252	-0.189570545	-0.030903840	0.073950596
## dimension_mean	0.236120382	-0.106390748	0.377436108	-0.518333769
## radius_se	-0.015625578	0.069635807	-0.011959877	0.111103952
## texture_se	-0.308499115	0.165408488	0.012614192	-0.033389049
## perimeter_se	-0.100597125	0.038865462	0.044358477	0.008991734
## area_se	-0.017226446	-0.055687709	-0.083203050	0.045171638
## smoothness_se	-0.293287983	-0.149148603	0.200139961	-0.018414232
## compactness_se	-0.263398426	-0.010320713	-0.491903153	-0.167886977
## concavity_se	0.251864823	-0.157777595	-0.135322845	-0.250292522
## points_se	-0.006430584	0.494527095	0.199547389	-0.062548716
## symmetry_se	0.319874237	-0.010836031	0.047340593	0.113219397
## dimension_se	0.275943072	0.240767973	-0.145958050	0.353782637
## radius_worst	0.039582217	0.138036550	-0.023526025	-0.166213790
## texture_worst	0.080142089	0.080737140	-0.053897961	-0.100862417
## perimeter_worst	-0.009084762	0.097004376	-0.012559001	-0.182407021
## area_worst	0.047986766	0.101235629	0.006646192	-0.315142865
## smoothness_worst	0.056931408	0.206026671	-0.163389545	-0.045226715
## compactness_worst	-0.371991007	-0.013117334	-0.165941776	0.049613607
## concavity_worst	-0.086870368	-0.218055908	0.066854662	0.204743734
## points_worst	-0.068367254	0.254345228	0.276401728	0.169597618
## symmetry_worst	0.043937722	0.256766084	-0.005448734	-0.139913723
## dimension_worst	-0.035134642	0.172524501	0.212520491	0.255448214
##	PC17	PC18	PC19	PC20
## id	-0.007779983	-0.019707372	0.005442248	0.020454908
## radius_mean	0.150008977	0.209908003	-0.156773206	0.211821385
## texture_mean	0.159152972	-0.034161758	0.040048687	0.029931705
## perimeter_mean	0.113792993	0.201233658	-0.168413120	0.227079273
## area_mean	0.130173978	0.251460456	-0.269145594	-0.045499625
## smoothness_mean	0.203117911	0.168171613	0.354463321	-0.160358262
## compactness_mean	-0.170379447	-0.016302860	-0.014259132	0.292092522
## concavity_mean	-0.270010606	-0.005071590	0.027973937	0.007197446
## points_mean	-0.381111880	0.028741889	0.087065594	-0.153991624
## symmetry_mean	0.165691481	-0.194702559	-0.169168737	-0.058503329
## dimension_mean	0.039119713	0.046298986	-0.086779501	-0.062879947
## radius_se	-0.055118880	-0.124562479	0.231233991	0.181436577
## texture_se	0.032768777	0.041652813	0.009177450	0.038681291
## perimeter_se	-0.023929011	-0.009084130	0.014508488	0.364045783
## area_se	-0.045538238	0.313148246	-0.296273515	-0.433949999
## smoothness_se	0.058326686	0.145306166	0.228819703	-0.013932678
## compactness_se	-0.190065826	-0.015610691	-0.094108380	-0.250216687
## concavity_se	0.126034946	0.092345618	-0.005794297	0.119490304
## points_se	0.197671940	0.106747906	-0.046944796	-0.015851066
## symmetry_se	0.158541381	-0.279918359	-0.180195394	-0.084242460
## dimension_se	-0.267180143	-0.122002438	0.059970839	0.097082660
## radius_worst	0.083459877	-0.235215809	0.218781792	0.027741137
## texture_worst	-0.185972310	0.065992656	-0.057250572	-0.080880841
## perimeter_worst	0.056649279	-0.228493742	0.189279122	0.105666112
## area_worst	0.090325036	-0.286471546	0.158722686	-0.393681440
## smoothness_worst	-0.142781922	-0.276751162	-0.504565504	0.228506719
## compactness_worst	0.153347954	-0.003683424	0.073627229	0.025544372
## concavity_worst	0.216302398	-0.190307542	0.107894455	-0.035839305
## points_worst	-0.178353485	-0.085180057	-0.067182996	-0.261323873
## symmetry_worst	-0.260033510	0.436706158	0.269313654	0.111738683
## dimension_worst	0.404957673	0.162920272	-0.026674889	-0.022516600
##	PC21	PC22	PC23	PC24
## id	0.009870917	0.006195707	0.003190337	-0.010289027
## radius_mean	0.046009507	0.070394387	-0.073021974	-0.098704322
## texture_mean	0.264801220	-0.436269565	-0.095890704	0.001311285
## perimeter_mean	0.015122205	0.070963404	-0.074821704	-0.040500943
## area_mean	0.087345298	0.021672998	-0.097428804	0.009396470
## smoothness_mean	-0.023842011	0.117945821	-0.063741313	-0.020088204
## compactness_mean	-0.476395571	-0.213187888	0.094254664	0.058295270
## concavity_mean	0.037771062	-0.001270114	0.188862925	0.321062737
## points_mean	0.231546040	0.017493297	0.313280824	-0.057974684
## symmetry_mean	-0.030776761	0.085067786	0.018331111	-0.052004767
## dimension_mean	0.172565576	0.085104005	-0.286892578	-0.084701081



## radius_se	0.090564458	-0.085660592	0.147793165	-0.263799753
## texture_se	0.083589382	-0.212168357	-0.048761201	-0.001150858
## perimeter_se	0.169586632	0.317246026	-0.153859020	0.081384223
## area_se	-0.270679518	-0.207916141	-0.068745790	0.110258620
## smoothness_se	-0.095370809	0.066602974	-0.051852247	-0.057154068
## compactness_se	0.451033960	0.159332265	0.048970757	0.003993806
## concavity_se	-0.070203251	-0.071023842	0.200850815	-0.388573085
## points_se	-0.064848884	-0.035557778	0.074494143	0.354040783
## symmetry_se	-0.112133933	0.092193625	0.084324570	-0.043455477
## dimension_se	-0.214213177	-0.069171668	-0.245408452	0.089594196
## radius_worst	0.006481267	-0.007068180	0.096292694	-0.057768458
## texture_worst	-0.330244412	0.578095532	0.111968438	-0.009473435
## perimeter_worst	-0.010544107	0.094457678	-0.014952244	0.058698441
## area_worst	-0.053510824	-0.149328216	0.096798702	0.193293235
## smoothness_worst	0.140127867	-0.156936236	0.069660581	0.091134610
## compactness_worst	-0.220884131	-0.191897773	-0.033373706	-0.145389941
## concavity_worst	0.047166544	0.139729448	-0.456817799	0.290302924
## points_worst	-0.039740929	-0.006870640	-0.305694162	-0.563297713
## symmetry_worst	0.125617213	-0.155827542	-0.096426675	0.122996111
## dimension_worst	0.095366679	0.092769737	0.470358007	0.002775112
##	PC25	PC26	PC27	PC28
## id	-0.004233388	-0.00132610	-0.002571324	-0.001623875
## radius_mean	-0.183664583	0.01859418	0.128713229	0.131697326
## texture_mean	0.099441545	-0.08442059	0.024821224	0.017622634
## perimeter_mean	-0.117262178	-0.02743488	0.124670225	0.115650274
## area_mean	0.070557041	0.21057100	-0.361014547	-0.467489167
## smoothness_mean	0.068940049	-0.02876100	0.037372832	-0.069482805
## compactness_mean	-0.102198309	-0.39651346	-0.262695425	-0.098624638
## concavity_mean	0.045550527	0.09717977	0.550227716	-0.363040016
## points_mean	0.082349955	0.18630114	-0.389316679	0.453345398
## symmetry_mean	0.018841491	0.02451053	0.015910368	0.015157593
## dimension_mean	-0.134601525	0.20670502	0.096796804	0.101343150
## radius_se	-0.561133900	0.17339784	-0.050411953	-0.213735821
## texture_se	0.023938591	-0.05709165	0.010893175	0.009925699
## perimeter_se	0.516048248	-0.07217201	-0.103485879	-0.041989200
## area_se	-0.018546693	-0.13093723	0.155929011	0.314758068
## smoothness_se	0.016193934	-0.03100551	0.008066566	0.009312365
## compactness_se	-0.122457873	-0.17364984	0.049404535	-0.046651501
## concavity_se	0.186159613	-0.01600952	-0.091931364	0.083824645
## points_se	-0.107166573	0.12999049	0.018674110	0.011675700
## symmetry_se	0.002613811	0.01936313	0.016991197	0.019891112
## dimension_se	0.076177800	0.08458109	-0.035156906	0.012141785
## radius_worst	-0.158114412	-0.07144112	0.195812320	0.178796461
## texture_worst	-0.118609952	0.11802219	-0.036347107	-0.021473842
## perimeter_worst	0.236463109	-0.11790535	0.243266456	0.241658719
## area_worst	0.146339946	0.03921251	-0.229813188	-0.237323945
## smoothness_worst	-0.011224935	0.04787154	-0.012860335	0.040730207
## compactness_worst	0.185437121	0.62471727	0.100772153	0.071087434
## concavity_worst	-0.286701322	-0.11586768	-0.267236886	0.142148446
## points_worst	0.105286798	-0.26352782	0.133749940	-0.230794105
## symmetry_worst	-0.013193455	-0.04505357	-0.027824916	-0.022695808
## dimension_worst	0.037882167	-0.28015574	-0.004500884	-0.060081371
##	PC29	PC30	PC31	
## id	-1.891724e-05	-0.0006852263	-7.122581e-05	
## radius_mean	2.111968e-01	-0.2114371011	-7.024325e-01	
## texture_mean	-6.362507e-05	0.0106165839	-2.644366e-04	
## perimeter_mean	8.434280e-02	-0.3838889617	6.898676e-01	
## area_mean	-2.725167e-01	0.4227208085	3.297173e-02	
## smoothness_mean	1.480038e-03	0.0034638648	4.850746e-03	
## compactness_mean	-5.466656e-03	0.0409079834	-4.468229e-02	
## concavity_mean	4.554138e-02	0.0101122808	-2.512860e-02	
## points_mean	-8.885707e-03	0.0041142627	1.067984e-03	
## symmetry_mean	1.432581e-03	0.0075571475	1.279594e-03	
## dimension_mean	-6.312291e-03	-0.0073311823	4.751885e-03	
## radius_se	-1.922290e-01	-0.1186768422	8.679321e-03	
## texture_se	-5.624974e-03	0.0086942153	1.063104e-03	
## perimeter_se	2.631905e-01	0.0060612569	-1.373310e-02	
## area_se	-4.205668e-02	0.0863645419	-1.054698e-03	
## smoothness_se	9.795835e-03	-0.0016737982	1.618711e-03	
## compactness_se	-1.539757e-02	-0.0032295613	-1.923037e-03	
## concavity_se	5.819985e-03	-0.0161202167	8.921294e-03	
## points_se	-2.900497e-02	0.0241014722	2.178643e-03	
## symmetry_se	-7.637856e-03	0.0051771158	-3.338380e-04	

```
## symmetry_worst      7.887888e-03  0.0001771188  0.000000e-01
## dimension_se        1.975791e-02  0.0083971145 -1.792802e-03
## radius_worst        4.126296e-01  0.6356796555  1.356846e-01
## texture_worst       -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst     -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst          2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst    -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst   4.869512e-02  0.0001075081  1.285262e-02
## concavity_worst     -1.764174e-02  0.0126547542 -4.031809e-04
## points_worst        2.247340e-02 -0.0353341030  2.276561e-03
## symmetry_worst      4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst     -2.356283e-02 -0.0115053741 -1.897779e-03
```

```
plot(breast_cancer_pca)
```



```
summary(breast_cancer_pca)
```

```
## Importance of components:
##              PC1      PC2      PC3      PC4      PC5      PC6
## Standard deviation    3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion 0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##              PC7      PC8      PC9     PC10     PC11     PC12
## Standard deviation    0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion 0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##              PC13     PC14     PC15     PC16     PC17     PC18
## Standard deviation    0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion 0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##              PC19     PC20     PC21     PC22     PC23     PC24
## Standard deviation    0.22293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion 0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##              PC25     PC26     PC27     PC28     PC29     PC30
## Standard deviation    0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion 0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##              PC31
## Standard deviation    0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion 1.00000
```

```
#View(breast_cancer_pca)
head(breast_cancer_pca$x)
```

```
##          PC1          PC2          PC3          PC4          PC5          PC6
## [1,] 2.501946 -0.09694805 -0.4489597  2.3341176  0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059  1.1542039  0.3362109  0.45962538  1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828  0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592  1.1172876  2.0502761  0.25303846 -1.5539634
## [5,] 2.500252  2.01035097 -0.7584035  1.9862169 -1.13537096  0.5940361
## [6,] 2.018308 -0.78242095  0.1125197 -0.6532280  0.01841577  0.6914453
##          PC7          PC8          PC9          PC10          PC11          PC12
## [1,] 0.5092015 -1.11423307  0.2840243  0.32463197 -0.3245353  0.04981306
## [2,] 0.2937434  0.10000461 -0.0668399  0.42612180  0.4564029  1.19357566
## [3,] -0.3303385  0.03599041  0.8734350  0.02222192  0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134  0.6254396  0.05666470 -0.0691646  0.97082409
## [5,] 0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533  0.03266208
## [6,] 0.1454026  0.06214539  0.2342454  0.73681239 -0.3671239 -0.77029743
##          PC13          PC14          PC15          PC16          PC17
## [1,] -0.19760220  0.1134403 -0.059302558  0.16637723 -0.04286656
## [2,] 0.01807424 -0.2824292 -0.204858888 -0.07067959  0.03088787
## [3,] 0.37435458  0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379  0.2179117 -0.665825669  0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881  0.22273309
## [6,] -0.49542291 -0.2992431  0.049952835 -0.20161083  0.14920422
##          PC18          PC19          PC20          PC21          PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170  0.05868642
## [3,] 0.327711259  0.15937793 -0.13804895 -0.13489743  0.10080029
## [4,] 0.197085181  0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054  0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568  0.18970936 -0.06872875  0.09669594
##          PC23          PC24          PC25          PC26          PC27
## [1,] -0.038971937  0.062212075  0.088438866  0.04872948 -0.007000724
## [2,] 0.070978613 -0.030822339 -0.016741580  0.04173030 -0.059332996
## [3,] 0.053909008  0.085484364  0.038277664 -0.04151896 -0.035546410
## [4,] 0.182045907  0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,] 0.043591030  0.008165322  0.002738052  0.05983731  0.046167735
## [6,] -0.001458054 -0.031338348  0.042784223 -0.08646068 -0.030944690
##          PC28          PC29          PC30          PC31
## [1,] 0.05356131  0.015184882  0.015985406  0.001396101
## [2,] -0.18696553  0.027011311 -0.000803330  0.008096490
## [3,] -0.07653067 -0.014640388  0.010307894  0.009074601
## [4,] -0.01711665 -0.047828494  0.023862995  0.000265075
## [5,] 0.03835364  0.032450800 -0.002312178 -0.002563269
## [6,] 0.00955434 -0.004403431  0.003869919 -0.002931194
```

```
# sample scores stored in breast_cancer_pca$x
# singular values (square roots of eigenvalues) stored in breast_cancer_pca$sdev
# loadings (eigenvectors) are stored in breast_cancer_pca$rotation
# variable means stored in breast_cancer_pca$center
# variable standard deviations stored in sparrows_pca$scale
# A table containing eigenvalues and %'s accounted, follows
# Eigenvalues are sdev^2
(eigen_breast_cancer <- breast_cancer_pca$sdev^2) ## brackets for print
```

```
## [1] 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
## [6] 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
## [11] 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
## [16] 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
## [21] 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
## [26] 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
## [31] 1.330402e-04
```

```
names(eigen_breast_cancer) <- paste("PC",1:31,sep="")
eigen_breast_cancer
```

```
##          PC1          PC2          PC3          PC4          PC5
## 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
##          PC6          PC7          PC8          PC9          PC10
## 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
##          PC11          PC12          PC13          PC14          PC15
## 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
##          PC16          PC17          PC18          PC19          PC20
## 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
##          PC21          PC22          PC23          PC24          PC25
## 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
##          PC26          PC27          PC28          PC29          PC30
## 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
##          PC31
## 1.330402e-04
```

```
sumlambdas <- sum(eigen_breast_cancer)
sumlambdas
```

```
## [1] 31
```

```
propvar <- eigen_breast_cancer/sumlambdas
propvar
```

```
##          PC1          PC2          PC3          PC4          PC5
## 4.286470e-01 1.837679e-01 9.146436e-02 6.391475e-02 5.318759e-02
##          PC6          PC7          PC8          PC9          PC10
## 3.982815e-02 3.155720e-02 2.166945e-02 1.486427e-02 1.300429e-02
##          PC11          PC12          PC13          PC14          PC15
## 1.126306e-02 9.480337e-03 8.424094e-03 7.784846e-03 5.063666e-03
##          PC16          PC17          PC18          PC19          PC20
## 3.036404e-03 2.574514e-03 1.904718e-03 1.696490e-03 1.584578e-03
##          PC21          PC22          PC23          PC24          PC25
## 1.002283e-03 9.658453e-04 8.848556e-04 7.822265e-04 5.819149e-04
##          PC26          PC27          PC28          PC29          PC30
## 4.993461e-04 2.636032e-04 2.225194e-04 5.126895e-05 2.414116e-05
##          PC31
## 4.291620e-06
```

```
summary(eigen_breast_cancer)
```

```
##      Min.   1st Qu.   Median     Mean   3rd Qu.     Max.
## 0.000133 0.025840 0.094129 1.000000 0.566273 13.288057
```

```
summary(breast_cancer_pca)
```

```
## Importance of components:
##          PC1      PC2      PC3      PC4      PC5      PC6
## Standard deviation    3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion 0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##          PC7      PC8      PC9      PC10     PC11     PC12
## Standard deviation    0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion 0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##          PC13     PC14     PC15     PC16     PC17     PC18
## Standard deviation    0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion 0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##          PC19     PC20     PC21     PC22     PC23     PC24
## Standard deviation    0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion 0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##          PC25     PC26     PC27     PC28     PC29     PC30
## Standard deviation    0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion 0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##          PC31
## Standard deviation    0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion 1.00000
```

```
cumvar_breast_cancer <- cumsum(propvar)
cumvar_breast_cancer
```

```
##          PC1      PC2      PC3      PC4      PC5      PC6      PC7
## 0.4286470 0.6124149 0.7038793 0.7677940 0.8209816 0.8608098 0.8923670
##          PC8      PC9      PC10     PC11     PC12     PC13     PC14
## 0.9140364 0.9289007 0.9419050 0.9531681 0.9626484 0.9710725 0.9788573
##          PC15     PC16     PC17     PC18     PC19     PC20     PC21
## 0.9839210 0.9869574 0.9895319 0.9914366 0.9931331 0.9947177 0.9957200
##          PC22     PC23     PC24     PC25     PC26     PC27     PC28
## 0.9966858 0.9975707 0.9983529 0.9989348 0.9994342 0.9996978 0.9999203
##          PC29     PC30     PC31
## 0.9999716 0.9999957 1.0000000
```

```
matlambdas <- rbind(eigen_breast_cancer,propvar,cumvar_breast_cancer)
rownames(matlambdas) <- c("Eigenvalues","Prop. variance","Cum. prop. variance")
round(matlambdas,4)
```

```
##          PC1      PC2      PC3      PC4      PC5      PC6      PC7
## Eigenvalues    13.2881 5.6968 2.8354 1.9814 1.6488 1.2347 0.9783
## Prop. variance  0.4286 0.1838 0.0915 0.0639 0.0532 0.0398 0.0316
## Cum. prop. variance 0.4286 0.6124 0.7039 0.7678 0.8210 0.8608 0.8924
##          PC8      PC9      PC10     PC11     PC12     PC13     PC14
## Eigenvalues    0.6718 0.4608 0.4031 0.3492 0.2939 0.2611 0.2413
## Prop. variance  0.0217 0.0149 0.0130 0.0113 0.0095 0.0084 0.0078
## Cum. prop. variance 0.9140 0.9289 0.9419 0.9532 0.9626 0.9711 0.9789
##          PC15     PC16     PC17     PC18     PC19     PC20     PC21
## Eigenvalues    0.1570 0.0941 0.0798 0.0590 0.0526 0.0491 0.0311
## Prop. variance  0.0051 0.0030 0.0026 0.0019 0.0017 0.0016 0.0010
## Cum. prop. variance 0.9839 0.9870 0.9895 0.9914 0.9931 0.9947 0.9957
##          PC22     PC23     PC24     PC25     PC26     PC27     PC28
## Eigenvalues    0.0299 0.0274 0.0242 0.0180 0.0155 0.0082 0.0069
## Prop. variance  0.0010 0.0009 0.0008 0.0006 0.0005 0.0003 0.0002
## Cum. prop. variance 0.9967 0.9976 0.9984 0.9989 0.9994 0.9997 0.9999
##          PC29     PC30     PC31
## Eigenvalues    0.0016 7e-04 1e-04
## Prop. variance  0.0001 0e+00 0e+00
## Cum. prop. variance 1.0000 1e+00 1e+00
```

```
summary(breast_cancer_pca)
```

```
## Importance of components:
##          PC1      PC2      PC3      PC4      PC5      PC6
## Standard deviation  3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion 0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##          PC7      PC8      PC9     PC10     PC11     PC12
## Standard deviation  0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion 0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##          PC13     PC14     PC15     PC16     PC17     PC18
## Standard deviation  0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion 0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##          PC19     PC20     PC21     PC22     PC23     PC24
## Standard deviation  0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion 0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##          PC25     PC26     PC27     PC28     PC29     PC30
## Standard deviation  0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion 0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##          PC31
## Standard deviation  0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion 1.00000
```

```
breast_cancer_pca$rotation
```

```
##          PC1      PC2      PC3      PC4
## id      -0.02291216  0.034068491  0.096938436 -0.026598045
## radius_mean -0.21891302  0.233271401 -0.011393786  0.042187950
## texture_mean -0.10384388  0.060044199  0.066892342 -0.602954308
## perimeter_mean -0.22753491  0.214589002 -0.012124791  0.042752797
## area_mean -0.22104577  0.230668816  0.026293150  0.054114724
## smoothness_mean -0.14241471 -0.186422211 -0.103182400  0.158098177
## compactness_mean -0.23906730 -0.152454726 -0.074768623  0.031818117
## concavity_mean -0.25828025 -0.060541625  0.001758736  0.019497124
## points_mean -0.26073811  0.034167392 -0.027579607  0.065785353
## symmetry_mean -0.13797774 -0.190684979 -0.040962032  0.067502543
## dimension_mean -0.06414779 -0.366531055 -0.020817875  0.047957856
## radius_se -0.20611747  0.105935702  0.266917221  0.099114446
## texture_se -0.01741339 -0.089547789  0.371439885 -0.356497230
## perimeter_se -0.21144652  0.089807043  0.264925682  0.090293055
## area_se -0.20307642  0.152771289  0.215790250  0.108568705
## smoothness_se -0.01467821 -0.203189876  0.311787845  0.044368664
## compactness_se -0.17028840 -0.232503362  0.154557465 -0.026425360
## concavity_se -0.15354367 -0.196846081  0.176560052  0.002248291
## points_se -0.18340675 -0.129965181  0.223850479  0.075252232
## symmetry_se -0.04241552 -0.183558627  0.285265066  0.046936126
## dimension_se -0.10249607 -0.279584139  0.211893354  0.016212450
## radius_worst -0.22800935  0.219296044 -0.049406340  0.015659705
## texture_worst -0.10451545  0.045501223 -0.039828934 -0.633119655
## perimeter_worst -0.23663734  0.199295985 -0.050431945  0.014068572
## area_worst -0.22493214  0.218985461 -0.013188891  0.025970672
## smoothness_worst -0.12782441 -0.172562959 -0.255328751  0.014523359
## compactness_worst -0.20988456 -0.144253637 -0.234513609 -0.092562168
## concavity_worst -0.22860218 -0.098526524 -0.172024941 -0.074807188
## points_worst -0.25074620  0.007534367 -0.170480673  0.005305980
## symmetry_worst -0.12267993 -0.142619436 -0.270515902 -0.037129466
## dimension_worst -0.13156024 -0.275702077 -0.229474476 -0.078971489
##          PC5      PC6      PC7      PC8
## id      0.011327587 -0.316733438  0.9071156324 -0.096362415
## radius_mean -0.038129861  0.029588521 -0.0422987777 -0.116427419
## texture_mean  0.049091450 -0.031394323  0.0149935618  0.001875482
## perimeter_mean -0.037715592  0.028394008 -0.0435888242 -0.106272097
## area_mean -0.010562229  0.006113155 -0.0289256668 -0.047414568
## smoothness_mean  0.365750055 -0.262508993 -0.1403403617 -0.123541189
## compactness_mean -0.011786637 -0.004903894 -0.0453031106  0.043145968
## concavity_mean -0.086512506 -0.002356338 -0.0325530646 -0.102436021
## points_mean  0.043667412 -0.034509273 -0.0814216298 -0.136923237
## symmetry_mean  0.305378893  0.335082168  0.1182592361 -0.098874531
```

##	dimension_mean	0.044767906	-0.112784169	-0.0410588768	0.306499872
##	radius_se	0.154254367	-0.023261199	0.0167882718	0.307415709
##	texture_se	0.190001500	0.022856912	-0.1902676469	-0.052632477
##	perimeter_se	0.120703357	0.003820151	0.0195081762	0.311265679
##	area_se	0.127765023	-0.051958835	0.0565606078	0.334287959
##	smoothness_se	0.232745603	-0.330867850	-0.0678348099	-0.260833914
##	compactness_se	-0.280298048	0.066788120	0.0222220211	0.021001944
##	concavity_se	-0.354164595	0.049699104	0.0336810725	-0.219193299
##	points_se	-0.195758558	-0.023197526	-0.0378517870	-0.370217167
##	symmetry_se	0.251331178	0.477530515	0.1184032606	-0.084854768
##	dimension_se	-0.263395188	-0.048462373	-0.0157602244	0.194418818
##	radius_worst	0.004280034	0.004521737	-0.0166458140	-0.007508307
##	texture_worst	0.092551860	-0.045174516	-0.0094601240	0.006617640
##	perimeter_worst	-0.007599144	0.012921166	-0.0145260986	0.002162488
##	area_worst	0.027413595	-0.024033338	-0.0007372602	0.066173186
##	smoothness_worst	0.325860028	-0.365048687	-0.0670682168	-0.116496117
##	compactness_worst	-0.121503371	0.034042714	0.0507556727	0.136509363
##	concavity_worst	-0.188280510	0.017962040	0.0352007117	-0.067085744
##	points_worst	-0.043123573	-0.029549100	-0.0207238959	-0.166500918
##	symmetry_worst	0.244245936	0.451404312	0.2340143294	-0.041439633
##	dimension_worst	-0.093699078	-0.092479698	0.0347167538	0.372034479
##		PC9	PC10	PC11	PC12
##	id	0.149115642	-0.16926751	0.058188997	-0.006721252
##	radius_mean	-0.046270835	-0.22402704	-0.079466081	-0.042213788
##	texture_mean	-0.088727168	0.11945674	-0.253258091	0.304032359
##	perimeter_mean	-0.036230738	-0.22634517	-0.069865929	-0.017573055
##	area_mean	-0.080649856	-0.18600385	-0.062795372	-0.110760120
##	smoothness_mean	0.278996404	-0.06133822	0.084661549	0.135321954
##	compactness_mean	0.099214048	-0.19518602	0.005172841	0.307036205
##	concavity_mean	0.075750464	0.03395563	0.134664686	-0.124553100
##	points_mean	0.116569072	-0.14261678	0.006124860	0.071564686
##	symmetry_mean	0.315150303	0.13561452	-0.574417320	-0.161058144
##	dimension_mean	0.130639482	-0.15848117	-0.066456112	0.037318709
##	radius_se	0.026200456	0.26504403	0.025847282	0.027030250
##	texture_se	0.372989606	-0.31521084	0.323158815	-0.348396233
##	perimeter_se	0.052860114	0.23789288	0.094867442	0.168501485
##	area_se	-0.030627892	0.24966405	0.071991560	-0.050731496
##	smoothness_se	-0.580789293	-0.01015980	-0.179568831	-0.081753374
##	compactness_se	-0.148593714	-0.11518343	-0.038615749	0.206959272
##	concavity_se	0.034715098	0.36592141	0.113536362	-0.348342358
##	points_se	0.189022962	0.21518752	-0.094066850	0.342855186
##	symmetry_se	-0.292785738	-0.22049558	0.328314881	0.185998712
##	dimension_se	-0.060203202	-0.22637997	-0.353844543	-0.250428852
##	radius_worst	-0.070224590	-0.09981025	-0.073013014	-0.105030701
##	texture_worst	-0.008571809	0.10669296	-0.038561250	-0.012490348
##	perimeter_worst	-0.058854223	-0.09821693	-0.045750979	-0.051125158
##	area_worst	-0.097034650	-0.06179787	-0.068822329	-0.184460981
##	smoothness_worst	-0.173257498	0.16912753	0.109278029	-0.142996001
##	compactness_worst	-0.111218083	-0.06445290	0.175401648	0.196805544
##	concavity_worst	-0.035467377	0.19661986	0.295581609	-0.184959562
##	points_worst	0.052322473	0.05121611	0.075496752	0.117518361
##	symmetry_worst	-0.188266324	0.10308901	0.019223451	-0.157210098
##	dimension_worst	-0.087222442	-0.11291399	-0.007071634	-0.118625115
##		PC13	PC14	PC15	PC16
##	id	-0.004841084	-0.006500099	0.006885943	-0.002753492
##	radius_mean	0.050603927	-0.012496988	-0.059054553	0.050789156
##	texture_mean	0.256273666	-0.201876125	0.020701124	0.108089530
##	perimeter_mean	0.038470392	-0.044684430	-0.048019221	0.039590476
##	area_mean	0.065047550	-0.067879244	-0.010152279	-0.014636050
##	smoothness_mean	0.315872261	-0.046461624	-0.444044654	0.117493291
##	compactness_mean	-0.104264618	-0.230005458	-0.007661166	-0.230759682
##	concavity_mean	0.065723393	-0.387349680	0.189733740	0.128386008
##	points_mean	0.042253113	-0.132637847	0.245219266	0.217299938
##	symmetry_mean	-0.288054252	-0.189570545	-0.030903840	0.073950596
##	dimension_mean	0.236120382	-0.106390748	0.377436108	-0.518333769
##	radius_se	-0.015625578	0.069635807	-0.011959877	0.111103952
##	texture_se	-0.308499115	0.165408488	0.012614192	-0.033389049
##	perimeter_se	-0.100597125	0.038865462	0.044358477	0.008991734
##	area_se	-0.017226446	-0.055687709	-0.083203050	0.045171638
##	smoothness_se	-0.293287983	-0.149148603	0.200139961	-0.018414232
##	compactness_se	-0.263398426	-0.010320713	-0.491903153	-0.167886977
##	concavity_se	0.251864823	-0.157777595	-0.135322845	-0.250292522
##	points_se	-0.006430584	0.484527095	0.188547388	-0.062548716

## points_se	-0.000430034	0.434327093	0.133347383	-0.002348710
## symmetry_se	0.319874237	-0.010836031	0.047340593	0.113219397
## dimension_se	0.275943072	0.240767973	-0.145958050	0.353782637
## radius_worst	0.039582217	0.138036550	-0.023526025	-0.166213790
## texture_worst	0.080142089	0.080737140	-0.053897961	-0.100862417
## perimeter_worst	-0.009084762	0.097004376	-0.012559001	-0.182407021
## area_worst	0.047986766	0.101235629	0.006646192	-0.315142865
## smoothness_worst	0.056931408	0.206026671	-0.163389545	-0.045226715
## compactness_worst	-0.371991007	-0.013117334	-0.165941776	0.049613607
## concavity_worst	-0.086870368	-0.218055908	0.066854662	0.204743734
## points_worst	-0.068367254	0.254345228	0.276401728	0.169597618
## symmetry_worst	0.043937722	0.256766084	-0.005448734	-0.139913723
## dimension_worst	-0.035134642	0.172524501	0.212520491	0.255448214
##	PC17	PC18	PC19	PC20
## id	-0.007779983	-0.019707372	0.005442248	0.020454908
## radius_mean	0.150008977	0.209908003	-0.156773206	0.211821385
## texture_mean	0.159152972	-0.034161758	0.040048687	0.029931705
## perimeter_mean	0.113792993	0.201233658	-0.168413120	0.227079273
## area_mean	0.130173978	0.251460456	-0.269145594	-0.045499625
## smoothness_mean	0.203117911	0.168171613	0.354463321	-0.160358262
## compactness_mean	-0.170379447	-0.016302860	-0.014259132	0.292092522
## concavity_mean	-0.270010606	-0.005071590	0.027973937	0.007197446
## points_mean	-0.381111880	0.028741889	0.087065594	-0.153991624
## symmetry_mean	0.165691481	-0.194702559	-0.169168737	-0.058503329
## dimension_mean	0.039119713	0.046298986	-0.086779501	-0.062879947
## radius_se	-0.055118880	-0.124562479	0.231233991	0.181436577
## texture_se	0.032768777	0.041652813	0.009177450	0.038681291
## perimeter_se	-0.023929011	-0.009084130	0.014508488	0.364045783
## area_se	-0.045538238	0.313148246	-0.296273515	-0.433949999
## smoothness_se	0.058326686	0.145306166	0.228819703	-0.013932678
## compactness_se	-0.190065826	-0.015610691	-0.094108380	-0.250216687
## concavity_se	0.126034946	0.092345618	-0.005794297	0.119490304
## points_se	0.197671940	0.106747906	-0.046944796	-0.015851066
## symmetry_se	0.158541381	-0.279918359	-0.180195394	-0.084242460
## dimension_se	-0.267180143	-0.122002438	0.059970839	0.097082660
## radius_worst	0.083459877	-0.235215809	0.218781792	0.027741137
## texture_worst	-0.185972310	0.065992656	-0.057250572	-0.080880841
## perimeter_worst	0.056649279	-0.228493742	0.189279122	0.105666112
## area_worst	0.090325036	-0.286471546	0.158722686	-0.393681440
## smoothness_worst	-0.142781922	-0.276751162	-0.504565504	0.228506719
## compactness_worst	0.153347954	-0.003683424	0.073627229	0.025544372
## concavity_worst	0.216302398	-0.190307542	0.107894455	-0.035839305
## points_worst	-0.178353485	-0.085180057	-0.067182996	-0.261323873
## symmetry_worst	-0.260033510	0.436706158	0.269313654	0.111738683
## dimension_worst	0.404957673	0.162920272	-0.026674889	-0.022516600
##	PC21	PC22	PC23	PC24
## id	0.009870917	0.006195707	0.003190337	-0.010289027
## radius_mean	0.046009507	0.070394387	-0.073021974	-0.098704322
## texture_mean	0.264801220	-0.436269565	-0.095890704	0.001311285
## perimeter_mean	0.015122205	0.070963404	-0.074821704	-0.040500943
## area_mean	0.087345298	0.021672998	-0.097428804	0.009396470
## smoothness_mean	-0.023842011	0.117945821	-0.063741313	-0.020088204
## compactness_mean	-0.476395571	-0.213187888	0.094254664	0.058295270
## concavity_mean	0.037771062	-0.001270114	0.188862925	0.321062737
## points_mean	0.231546040	0.017493297	0.313280824	-0.057974684
## symmetry_mean	-0.030776761	0.085067786	0.018331111	-0.052004767
## dimension_mean	0.172565576	0.085104005	-0.286892578	-0.084701081
## radius_se	0.090564458	-0.085660592	0.147793165	-0.263799753
## texture_se	0.083589382	-0.212168357	-0.048761201	-0.001150858
## perimeter_se	0.169586632	0.317246026	-0.153859020	0.081384223
## area_se	-0.270679518	-0.207916141	-0.068745790	0.110258620
## smoothness_se	-0.095370809	0.066602974	-0.051852247	-0.057154068
## compactness_se	0.451033960	0.159332265	0.048970757	0.003993806
## concavity_se	-0.070203251	-0.071023842	0.200850815	-0.388573085
## points_se	-0.064848884	-0.035557778	0.074494143	0.354040783
## symmetry_se	-0.112133933	0.092193625	0.084324570	-0.043455477
## dimension_se	-0.214213177	-0.069171668	-0.245408452	0.089594196
## radius_worst	0.006481267	-0.007068180	0.096292694	-0.057768458
## texture_worst	-0.330244412	0.578095532	0.111968438	-0.009473435
## perimeter_worst	-0.010544107	0.094457678	-0.014952244	0.058698441
## area_worst	-0.053510824	-0.149328216	0.096798702	0.193293235
## smoothness_worst	0.140127867	-0.156936236	0.069660581	0.091134610
## compactness_worst	-0.220884131	-0.191897773	-0.033373706	-0.145389941



```

## concavity_worst      0.047166544  0.139729448 -0.456817799  0.290302924
## points_worst        -0.039740929 -0.006870640 -0.305694162 -0.563297713
## symmetry_worst      0.125617213 -0.155827542 -0.096426675  0.122996111
## dimension_worst     0.095366679  0.092769737  0.470358007  0.002775112
##
##          PC25          PC26          PC27          PC28
## id                -0.004233388 -0.00132610 -0.002571324 -0.001623875
## radius_mean       -0.183664583  0.01859418  0.128713229  0.131697326
## texture_mean       0.099441545 -0.08442059  0.024821224  0.017622634
## perimeter_mean    -0.117262178 -0.02743488  0.124670225  0.115650274
## area_mean          0.070557041  0.21057100 -0.361014547 -0.467489167
## smoothness_mean    0.068940049 -0.02876100  0.037372832 -0.069482805
## compactness_mean  -0.102198309 -0.39651346 -0.262695425 -0.098624638
## concavity_mean     0.045550527  0.09717977  0.550227716 -0.363040016
## points_mean        0.082349955  0.18630114 -0.389316679  0.453345398
## symmetry_mean       0.018841491  0.02451053  0.015910368  0.015157593
## dimension_mean     -0.134601525  0.20670502  0.096796804  0.101343150
## radius_se          -0.561133900  0.17339784 -0.050411953 -0.213735821
## texture_se          0.023938591 -0.05709165  0.010893175  0.009925699
## perimeter_se        0.516048248 -0.07217201 -0.103485879 -0.041989200
## area_se            -0.018546693 -0.13093723  0.155929011  0.314758068
## smoothness_se       0.016193934 -0.03100551  0.008066566  0.009312365
## compactness_se     -0.122457873 -0.17364984  0.049404535 -0.046651501
## concavity_se        0.186159613 -0.01600952 -0.091931364  0.083824645
## points_se          -0.107166573  0.12999049  0.018674110  0.011675700
## symmetry_se         0.002613811  0.01936313  0.016991197  0.019891112
## dimension_se        0.076177800  0.08458109 -0.035156906  0.012141785
## radius_worst       -0.158114412 -0.07144112  0.195812320  0.178796461
## texture_worst       -0.118609952  0.11802219 -0.036347107 -0.021473842
## perimeter_worst     0.236463109 -0.11790535  0.243266456  0.241658719
## area_worst          0.146339946  0.03921251 -0.229813188 -0.237323945
## smoothness_worst   -0.011224935  0.04787154 -0.012860335  0.040730207
## compactness_worst   0.185437121  0.62471727  0.100772153  0.071087434
## concavity_worst    -0.286701322 -0.11586768 -0.267236886  0.142148446
## points_worst        0.105286798 -0.26352782  0.133749940 -0.230794105
## symmetry_worst      -0.013193455 -0.04505357 -0.027824916 -0.022695808
## dimension_worst     0.037882167 -0.28015574 -0.004500884 -0.060081371
##
##          PC29          PC30          PC31
## id                -1.891724e-05 -0.0006852263 -7.122581e-05
## radius_mean        2.111968e-01 -0.2114371011 -7.024325e-01
## texture_mean        -6.362507e-05  0.0106165839 -2.644366e-04
## perimeter_mean      8.434280e-02 -0.3838889617  6.898676e-01
## area_mean           -2.725167e-01  0.4227208085  3.297173e-02
## smoothness_mean     1.480038e-03  0.0034638648  4.850746e-03
## compactness_mean    -5.466656e-03  0.0409079834 -4.468229e-02
## concavity_mean      4.554138e-02  0.0101122808 -2.512860e-02
## points_mean         -8.885707e-03  0.0041142627  1.067984e-03
## symmetry_mean        1.432581e-03  0.0075571475  1.279594e-03
## dimension_mean      -6.312291e-03 -0.0073311823  4.751885e-03
## radius_se          -1.922290e-01 -0.1186768422  8.679321e-03
## texture_se          -5.624974e-03  0.0086942153  1.063104e-03
## perimeter_se        2.631905e-01  0.0060612569 -1.373310e-02
## area_se             -4.205668e-02  0.0863645419 -1.054698e-03
## smoothness_se       9.795835e-03 -0.0016737982  1.618711e-03
## compactness_se     -1.539757e-02 -0.0032295613 -1.923037e-03
## concavity_se        5.819985e-03 -0.0161202167  8.921294e-03
## points_se          -2.900497e-02  0.0241014722  2.178643e-03
## symmetry_se         -7.637856e-03  0.0051771158 -3.338380e-04
## dimension_se        1.975791e-02  0.0083971145 -1.792802e-03
## radius_worst        4.126296e-01  0.6356796555  1.356846e-01
## texture_worst       -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst     -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst          2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst    -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst   4.869512e-02  0.0001075081  1.285262e-02
## concavity_worst     -1.764174e-02  0.0126547542 -4.031809e-04
## points_worst        2.247340e-02 -0.0353341030  2.276561e-03
## symmetry_worst       4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst     -2.356283e-02 -0.0115053741 -1.897779e-03

```

```
print(breast_cancer_pca)
```

```
## Standard deviations (1 to n=31):
```

```
## standard deviations (1, ..., p-31):
## [1] 3.64527878 2.38679814 1.68386313 1.40760690 1.28406203 1.11115827
## [7] 0.98907696 0.81960537 0.67881693 0.63492763 0.59089337 0.54211662
## [13] 0.51102537 0.49125372 0.39619900 0.30680373 0.28250655 0.24299439
## [19] 0.22932770 0.22163467 0.17626907 0.17303527 0.16562163 0.15572098
## [25] 0.13431069 0.12441756 0.09039745 0.08305482 0.03986650 0.02735646
## [31] 0.01153431
##
## Rotation (n x k) = (31 x 31):
##
##          PC1          PC2          PC3          PC4
## id      -0.02291216  0.034068491  0.096938436 -0.026598045
## radius_mean -0.21891302  0.233271401 -0.011393786  0.042187950
## texture_mean -0.10384388  0.060044199  0.066892342 -0.602954308
## perimeter_mean -0.22753491  0.214589002 -0.012124791  0.042752797
## area_mean -0.22104577  0.230668816  0.026293150  0.054114724
## smoothness_mean -0.14241471 -0.186422211 -0.103182400  0.158098177
## compactness_mean -0.23906730 -0.152454726 -0.074768623  0.031818117
## concavity_mean -0.25828025 -0.060541625  0.001758736  0.019497124
## points_mean -0.26073811  0.034167392 -0.027579607  0.065785353
## symmetry_mean -0.13797774 -0.190684979 -0.040962032  0.067502543
## dimension_mean -0.06414779 -0.366531055 -0.020817875  0.047957856
## radius_se -0.20611747  0.105935702  0.266917221  0.099114446
## texture_se -0.01741339 -0.089547789  0.371439885 -0.356497230
## perimeter_se -0.21144652  0.089807043  0.264925682  0.090293055
## area_se -0.20307642  0.152771289  0.215790250  0.108568705
## smoothness_se -0.01467821 -0.203189876  0.311787845  0.044368664
## compactness_se -0.17028840 -0.232503362  0.154557465 -0.026425360
## concavity_se -0.15354367 -0.196846081  0.176560052  0.002248291
## points_se -0.18340675 -0.129965181  0.223850479  0.075252232
## symmetry_se -0.04241552 -0.183558627  0.285265066  0.046936126
## dimension_se -0.10249607 -0.279584139  0.211893354  0.016212450
## radius_worst -0.22800935  0.219296044 -0.049406340  0.015659705
## texture_worst -0.10451545  0.045501223 -0.039828934 -0.633119655
## perimeter_worst -0.23663734  0.199295985 -0.050431945  0.014068572
## area_worst -0.22493214  0.218985461 -0.013188891  0.025970672
## smoothness_worst -0.12782441 -0.172562959 -0.255328751  0.014523359
## compactness_worst -0.20988456 -0.144253637 -0.234513609 -0.092562168
## concavity_worst -0.22860218 -0.098526524 -0.172024941 -0.074807188
## points_worst -0.25074620  0.007534367 -0.170480673  0.005305980
## symmetry_worst -0.12267993 -0.142619436 -0.270515902 -0.037129466
## dimension_worst -0.13156024 -0.275702077 -0.229474476 -0.078971489
##
##          PC5          PC6          PC7          PC8
## id      0.011327587 -0.316733438  0.9071156324 -0.096362415
## radius_mean -0.038129861  0.029588521 -0.0422987777 -0.116427419
## texture_mean  0.049091450 -0.031394323  0.0149935618  0.001875482
## perimeter_mean -0.037715592  0.028394008 -0.0435888242 -0.106272097
## area_mean -0.010562229  0.006113155 -0.0289256668 -0.047414568
## smoothness_mean  0.365750055 -0.262508993 -0.1403403617 -0.123541189
## compactness_mean -0.011786637 -0.004903894 -0.0453031106  0.043145968
## concavity_mean -0.086512506 -0.002356338 -0.0325530646 -0.102436021
## points_mean  0.043667412 -0.034509273 -0.0814216298 -0.136923237
## symmetry_mean  0.305378893  0.335082168  0.1182592361 -0.098874531
## dimension_mean  0.044767906 -0.112784169 -0.0410588768  0.306499872
## radius_se  0.154254367 -0.023261199  0.0167882718  0.307415709
## texture_se  0.190001500  0.022856912 -0.1902676469 -0.052632477
## perimeter_se  0.120703357  0.003820151  0.0195081762  0.311265679
## area_se  0.127765023 -0.051958835  0.0565606078  0.334287959
## smoothness_se  0.232745603 -0.330867850 -0.0678348099 -0.260833914
## compactness_se -0.280298048  0.066788120  0.0222220211  0.021001944
## concavity_se -0.354164595  0.049699104  0.0336810725 -0.219193299
## points_se -0.195758558 -0.023197526 -0.0378517870 -0.370217167
## symmetry_se  0.251331178  0.477530515  0.1184032606 -0.084854768
## dimension_se -0.263395188 -0.048462373 -0.0157602244  0.194418818
## radius_worst  0.004280034  0.004521737 -0.0166458140 -0.007508307
## texture_worst  0.092551860 -0.045174516 -0.0094601240  0.006617640
## perimeter_worst -0.007599144  0.012921166 -0.0145260986  0.002162488
## area_worst  0.027413595 -0.024033338 -0.0007372602  0.066173186
## smoothness_worst  0.325860028 -0.365048687 -0.0670682168 -0.116496117
## compactness_worst -0.121503371  0.034042714  0.0507556727  0.136509363
## concavity_worst -0.188280510  0.017962040  0.0352007117 -0.067085744
## points_worst -0.043123573 -0.029549100 -0.0207238959 -0.166500918
## symmetry_worst  0.244245936  0.451404312  0.2340143294 -0.041439633
## dimension_worst -0.093699078 -0.092479698  0.0347167538  0.372034479
```

##	PC9	PC10	PC11	PC12
## id	0.149115642	-0.16926751	0.058188997	-0.006721252
## radius_mean	-0.046270835	-0.22402704	-0.079466081	-0.042213788
## texture_mean	-0.088727168	0.11945674	-0.253258091	0.304032359
## perimeter_mean	-0.036230738	-0.22634517	-0.069865929	-0.017573055
## area_mean	-0.080649856	-0.18600385	-0.062795372	-0.110760120
## smoothness_mean	0.278996404	-0.06133822	0.084661549	0.135321954
## compactness_mean	0.099214048	-0.19518602	0.005172841	0.307036205
## concavity_mean	0.075750464	0.03395563	0.134664686	-0.124553100
## points_mean	0.116569072	-0.14261678	0.006124860	0.071564686
## symmetry_mean	0.315150303	0.13561452	-0.574417320	-0.161058144
## dimension_mean	0.130639482	-0.15848117	-0.066456112	0.037318709
## radius_se	0.026200456	0.26504403	0.025847282	0.027030250
## texture_se	0.372989606	-0.31521084	0.323158815	-0.348396233
## perimeter_se	0.052860114	0.23789288	0.094867442	0.168501485
## area_se	-0.030627892	0.24966405	0.071991560	-0.050731496
## smoothness_se	-0.580789293	-0.01015980	-0.179568831	-0.081753374
## compactness_se	-0.148593714	-0.11518343	-0.038615749	0.206959272
## concavity_se	0.034715098	0.36592141	0.113536362	-0.348342358
## points_se	0.189022962	0.21518752	-0.094066850	0.342855186
## symmetry_se	-0.292785738	-0.22049558	0.328314881	0.185998712
## dimension_se	-0.060203202	-0.22637997	-0.353844543	-0.250428852
## radius_worst	-0.070224590	-0.09981025	-0.073013014	-0.105030701
## texture_worst	-0.008571809	0.10669296	-0.038561250	-0.012490348
## perimeter_worst	-0.058854223	-0.09821693	-0.045750979	-0.051125158
## area_worst	-0.097034650	-0.06179787	-0.068822329	-0.184460981
## smoothness_worst	-0.173257498	0.16912753	0.109278029	-0.142996001
## compactness_worst	-0.111218083	-0.06445290	0.175401648	0.196805544
## concavity_worst	-0.035467377	0.19661986	0.295581609	-0.184959562
## points_worst	0.052322473	0.05121611	0.075496752	0.117518361
## symmetry_worst	-0.188266324	0.10308901	0.019223451	-0.157210098
## dimension_worst	-0.087222442	-0.11291399	-0.007071634	-0.118625115
##	PC13	PC14	PC15	PC16
## id	-0.004841084	-0.006500099	0.006885943	-0.002753492
## radius_mean	0.050603927	-0.012496988	-0.059054553	0.050789156
## texture_mean	0.256273666	-0.201876125	0.020701124	0.108089530
## perimeter_mean	0.038470392	-0.044684430	-0.048019221	0.039590476
## area_mean	0.065047550	-0.067879244	-0.010152279	-0.014636050
## smoothness_mean	0.315872261	-0.046461624	-0.444044654	0.117493291
## compactness_mean	-0.104264618	-0.230005458	-0.007661166	-0.230759682
## concavity_mean	0.065723393	-0.387349680	0.189733740	0.128386008
## points_mean	0.042253113	-0.132637847	0.245219266	0.217299938
## symmetry_mean	-0.288054252	-0.189570545	-0.030903840	0.073950596
## dimension_mean	0.236120382	-0.106390748	0.377436108	-0.518333769
## radius_se	-0.015625578	0.069635807	-0.011959877	0.111103952
## texture_se	-0.308499115	0.165408488	0.012614192	-0.033389049
## perimeter_se	-0.100597125	0.038865462	0.044358477	0.008991734
## area_se	-0.017226446	-0.055687709	-0.083203050	0.045171638
## smoothness_se	-0.293287983	-0.149148603	0.200139961	-0.018414232
## compactness_se	-0.263398426	-0.010320713	-0.491903153	-0.167886977
## concavity_se	0.251864823	-0.157777595	-0.135322845	-0.250292522
## points_se	-0.006430584	0.494527095	0.199547389	-0.062548716
## symmetry_se	0.319874237	-0.010836031	0.047340593	0.113219397
## dimension_se	0.275943072	0.240767973	-0.145958050	0.353782637
## radius_worst	0.039582217	0.138036550	-0.023526025	-0.166213790
## texture_worst	0.080142089	0.080737140	-0.053897961	-0.100862417
## perimeter_worst	-0.009084762	0.097004376	-0.012559001	-0.182407021
## area_worst	0.047986766	0.101235629	0.006646192	-0.315142865
## smoothness_worst	0.056931408	0.206026671	-0.163389545	-0.045226715
## compactness_worst	-0.371991007	-0.013117334	-0.165941776	0.049613607
## concavity_worst	-0.086870368	-0.218055908	0.066854662	0.204743734
## points_worst	-0.068367254	0.254345228	0.276401728	0.169597618
## symmetry_worst	0.043937722	0.256766084	-0.005448734	-0.139913723
## dimension_worst	-0.035134642	0.172524501	0.212520491	0.255448214
##	PC17	PC18	PC19	PC20
## id	-0.007779983	-0.019707372	0.005442248	0.020454908
## radius_mean	0.150008977	0.209908003	-0.156773206	0.211821385
## texture_mean	0.159152972	-0.034161758	0.040048687	0.029931705
## perimeter_mean	0.113792993	0.201233658	-0.168413120	0.227079273
## area_mean	0.130173978	0.251460456	-0.269145594	-0.045499625
## smoothness_mean	0.203117911	0.168171613	0.354463321	-0.160358262
## compactness_mean	-0.170379447	-0.016302860	-0.014259132	0.292092522
## concavity_mean	-0.270010606	-0.005071590	0.027973937	0.007197446

##	points_mean	-0.381111880	0.028741889	0.087065594	-0.153991624
##	symmetry_mean	0.165691481	-0.194702559	-0.169168737	-0.058503329
##	dimension_mean	0.039119713	0.046298986	-0.086779501	-0.062879947
##	radius_se	-0.055118880	-0.124562479	0.231233991	0.181436577
##	texture_se	0.032768777	0.041652813	0.009177450	0.038681291
##	perimeter_se	-0.023929011	-0.009084130	0.014508488	0.364045783
##	area_se	-0.045538238	0.313148246	-0.296273515	-0.433949999
##	smoothness_se	0.058326686	0.145306166	0.228819703	-0.013932678
##	compactness_se	-0.190065826	-0.015610691	-0.094108380	-0.250216687
##	concavity_se	0.126034946	0.092345618	-0.005794297	0.119490304
##	points_se	0.197671940	0.106747906	-0.046944796	-0.015851066
##	symmetry_se	0.158541381	-0.279918359	-0.180195394	-0.084242460
##	dimension_se	-0.267180143	-0.122002438	0.059970839	0.097082660
##	radius_worst	0.083459877	-0.235215809	0.218781792	0.027741137
##	texture_worst	-0.185972310	0.065992656	-0.057250572	-0.080880841
##	perimeter_worst	0.056649279	-0.228493742	0.189279122	0.105666112
##	area_worst	0.090325036	-0.286471546	0.158722686	-0.393681440
##	smoothness_worst	-0.142781922	-0.276751162	-0.504565504	0.228506719
##	compactness_worst	0.153347954	-0.003683424	0.073627229	0.025544372
##	concavity_worst	0.216302398	-0.190307542	0.107894455	-0.035839305
##	points_worst	-0.178353485	-0.085180057	-0.067182996	-0.261323873
##	symmetry_worst	-0.260033510	0.436706158	0.269313654	0.111738683
##	dimension_worst	0.404957673	0.162920272	-0.026674889	-0.022516600
##		PC21	PC22	PC23	PC24
##	id	0.009870917	0.006195707	0.003190337	-0.010289027
##	radius_mean	0.046009507	0.070394387	-0.073021974	-0.098704322
##	texture_mean	0.264801220	-0.436269565	-0.095890704	0.001311285
##	perimeter_mean	0.015122205	0.070963404	-0.074821704	-0.040500943
##	area_mean	0.087345298	0.021672998	-0.097428804	0.009396470
##	smoothness_mean	-0.023842011	0.117945821	-0.063741313	-0.020088204
##	compactness_mean	-0.0476395571	-0.213187888	0.094254664	0.058295270
##	concavity_mean	0.037771062	-0.001270114	0.188862925	0.321062737
##	points_mean	0.231546040	0.017493297	0.313280824	-0.057974684
##	symmetry_mean	-0.030776761	0.085067786	0.018331111	-0.052004767
##	dimension_mean	0.172565576	0.085104005	-0.286892578	-0.084701081
##	radius_se	0.090564458	-0.085660592	0.147793165	-0.263799753
##	texture_se	0.083589382	-0.212168357	-0.048761201	-0.001150858
##	perimeter_se	0.169586632	0.317246026	-0.153859020	0.081384223
##	area_se	-0.270679518	-0.207916141	-0.068745790	0.110258620
##	smoothness_se	-0.095370809	0.066602974	-0.051852247	-0.057154068
##	compactness_se	0.451033960	0.159332265	0.048970757	0.003993806
##	concavity_se	-0.070203251	-0.071023842	0.200850815	-0.388573085
##	points_se	-0.064848884	-0.035557778	0.074494143	0.354040783
##	symmetry_se	-0.112133933	0.092193625	0.084324570	-0.043455477
##	dimension_se	-0.214213177	-0.069171668	-0.245408452	0.089594196
##	radius_worst	0.006481267	-0.007068180	0.096292694	-0.057768458
##	texture_worst	-0.330244412	0.578095532	0.111968438	-0.009473435
##	perimeter_worst	-0.010544107	0.094457678	-0.014952244	0.058698441
##	area_worst	-0.053510824	-0.149328216	0.096798702	0.193293235
##	smoothness_worst	0.140127867	-0.156936236	0.069660581	0.091134610
##	compactness_worst	-0.220884131	-0.191897773	-0.033373706	-0.145389941
##	concavity_worst	0.047166544	0.139729448	-0.456817799	0.290302924
##	points_worst	-0.039740929	-0.006870640	-0.305694162	-0.563297713
##	symmetry_worst	0.125617213	-0.155827542	-0.096426675	0.122996111
##	dimension_worst	0.095366679	0.092769737	0.470358007	0.002775112
##		PC25	PC26	PC27	PC28
##	id	-0.004233388	-0.00132610	-0.002571324	-0.001623875
##	radius_mean	-0.183664583	0.01859418	0.128713229	0.131697326
##	texture_mean	0.099441545	-0.08442059	0.024821224	0.017622634
##	perimeter_mean	-0.117262178	-0.02743488	0.124670225	0.115650274
##	area_mean	0.070557041	0.21057100	-0.361014547	-0.467489167
##	smoothness_mean	0.068940049	-0.02876100	0.037372832	-0.069482805
##	compactness_mean	-0.102198309	-0.39651346	-0.262695425	-0.098624638
##	concavity_mean	0.045550527	0.09717977	0.550227716	-0.363040016
##	points_mean	0.082349955	0.18630114	-0.389316679	0.453345398
##	symmetry_mean	0.018841491	0.02451053	0.015910368	0.015157593
##	dimension_mean	-0.134601525	0.20670502	0.096796804	0.101343150
##	radius_se	-0.561133900	0.17339784	-0.050411953	-0.213735821
##	texture_se	0.023938591	-0.05709165	0.010893175	0.009925699
##	perimeter_se	0.516048248	-0.07217201	-0.103485879	-0.041989200
##	area_se	-0.018546693	-0.13093723	0.155929011	0.314758068
##	smoothness_se	0.016193934	-0.03100551	0.008066566	0.009312365
##	compactness_se	-0.122457873	-0.17364984	0.049404535	-0.046651501

```
## compactness_se -0.122497873 -0.17304984 0.049404933 -0.040031001
## concavity_se 0.186159613 -0.01600952 -0.091931364 0.083824645
## points_se -0.107166573 0.12999049 0.018674110 0.011675700
## symmetry_se 0.002613811 0.01936313 0.016991197 0.019891112
## dimension_se 0.076177800 0.08458109 -0.035156906 0.012141785
## radius_worst -0.158114412 -0.07144112 0.195812320 0.178796461
## texture_worst -0.118609952 0.11802219 -0.036347107 -0.021473842
## perimeter_worst 0.236463109 -0.11790535 0.243266456 0.241658719
## area_worst 0.146339946 0.03921251 -0.229813188 -0.237323945
## smoothness_worst -0.011224935 0.04787154 -0.012860335 0.040730207
## compactness_worst 0.185437121 0.62471727 0.100772153 0.071087434
## concavity_worst -0.286701322 -0.11586768 -0.267236886 0.142148446
## points_worst 0.105286798 -0.26352782 0.133749940 -0.230794105
## symmetry_worst -0.013193455 -0.04505357 -0.027824916 -0.022695808
## dimension_worst 0.037882167 -0.28015574 -0.004500884 -0.060081371
## PC29 PC30 PC31
## id -1.891724e-05 -0.0006852263 -7.122581e-05
## radius_mean 2.111968e-01 -0.2114371011 -7.024325e-01
## texture_mean -6.362507e-05 0.0106165839 -2.644366e-04
## perimeter_mean 8.434280e-02 -0.3838889617 6.898676e-01
## area_mean -2.725167e-01 0.4227208085 3.297173e-02
## smoothness_mean 1.480038e-03 0.0034638648 4.850746e-03
## compactness_mean -5.466656e-03 0.0409079834 -4.468229e-02
## concavity_mean 4.554138e-02 0.0101122808 -2.512860e-02
## points_mean -8.885707e-03 0.0041142627 1.067984e-03
## symmetry_mean 1.432581e-03 0.0075571475 1.279594e-03
## dimension_mean -6.312291e-03 -0.0073311823 4.751885e-03
## radius_se -1.922290e-01 -0.1186768422 8.679321e-03
## texture_se -5.624974e-03 0.0086942153 1.063104e-03
## perimeter_se 2.631905e-01 0.0060612569 -1.373310e-02
## area_se -4.205668e-02 0.0863645419 -1.054698e-03
## smoothness_se 9.795835e-03 -0.0016737982 1.618711e-03
## compactness_se -1.539757e-02 -0.0032295613 -1.923037e-03
## concavity_se 5.819985e-03 -0.0161202167 8.921294e-03
## points_se -2.900497e-02 0.0241014722 2.178643e-03
## symmetry_se -7.637856e-03 0.0051771158 -3.338380e-04
## dimension_se 1.975791e-02 0.0083971145 -1.792802e-03
## radius_worst 4.126296e-01 0.6356796555 1.356846e-01
## texture_worst -3.896988e-04 -0.0172219636 -1.020237e-03
## perimeter_worst -7.286790e-01 -0.0228830657 -7.974244e-02
## area_worst 2.389679e-01 -0.4448733182 -3.976788e-02
## smoothness_worst -1.535941e-03 -0.0074142082 -4.586820e-03
## compactness_worst 4.869512e-02 0.0001075081 1.285262e-02
## concavity_worst -1.764174e-02 0.0126547542 -4.031809e-04
## points_worst 2.247340e-02 -0.0353341030 2.276561e-03
## symmetry_worst 4.922100e-03 -0.0133523613 -3.910451e-04
## dimension_worst -2.356283e-02 -0.0115053741 -1.897779e-03
```

```
# Sample scores stored in breast_cancer_pca$x
head(breast_cancer_pca$x)
```

```
##          PC1          PC2          PC3          PC4          PC5          PC6
## [1,] 2.501946 -0.09694805 -0.4489597 2.3341176 0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059 1.1542039 0.3362109 0.45962538 1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828 0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592 1.1172876 2.0502761 0.25303846 -1.5539634
## [5,] 2.500252 2.01035097 -0.7584035 1.9862169 -1.13537096 0.5940361
## [6,] 2.018308 -0.78242095 0.1125197 -0.6532280 0.01841577 0.6914453
##          PC7          PC8          PC9          PC10          PC11          PC12
## [1,] 0.5092015 -1.11423307 0.2840243 0.32463197 -0.3245353 0.04981306
## [2,] 0.2937434 0.10000461 -0.0668399 0.42612180 0.4564029 1.19357566
## [3,] -0.3303385 0.03599041 0.8734350 0.02222192 0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134 0.6254396 0.05666470 -0.0691646 0.97082409
## [5,] 0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533 0.03266208
## [6,] 0.1454026 0.06214539 0.2342454 0.73681239 -0.3671239 -0.77029743
##          PC13          PC14          PC15          PC16          PC17
## [1,] -0.19760220 0.1134403 -0.059302558 0.16637723 -0.04286656
## [2,] 0.01807424 -0.2824292 -0.204858888 -0.07067959 0.03088787
## [3,] 0.37435458 0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379 0.2179117 -0.665825669 0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881 0.22273309
## [6,] -0.49542291 -0.2992431 0.049952835 -0.20161083 0.14920422
##          PC18          PC19          PC20          PC21          PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170 0.05868642
## [3,] 0.327711259 0.15937793 -0.13804895 -0.13489743 0.10080029
## [4,] 0.197085181 0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054 0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568 0.18970936 -0.06872875 0.09669594
##          PC23          PC24          PC25          PC26          PC27
## [1,] -0.038971937 0.062212075 0.088438866 0.04872948 -0.007000724
## [2,] 0.070978613 -0.030822339 -0.016741580 0.04173030 -0.059332996
## [3,] 0.053909008 0.085484364 0.038277664 -0.04151896 -0.035546410
## [4,] 0.182045907 0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,] 0.043591030 0.008165322 0.002738052 0.05983731 0.046167735
## [6,] -0.001458054 -0.031338348 0.042784223 -0.08646068 -0.030944690
##          PC28          PC29          PC30          PC31
## [1,] 0.05356131 0.015184882 0.015985406 0.001396101
## [2,] -0.18696553 0.027011311 -0.000803330 0.008096490
## [3,] -0.07653067 -0.014640388 0.010307894 0.009074601
## [4,] -0.01711665 -0.047828494 0.023862995 0.000265075
## [5,] 0.03835364 0.032450800 -0.002312178 -0.002563269
## [6,] 0.00955434 -0.004403431 0.003869919 -0.002931194
```

```
# Identifying the scores by their diagnosis
diag_pca <- cbind(data.frame(diagnosis),breast_cancer_pca$x)
head(diag_pca)
```

```
##      diagnosis      PC1      PC2      PC3      PC4      PC5
## 1      B 2.501946 -0.09694805 -0.4489597 2.3341176 0.69771548
## 2      B 1.467439 -1.68630059 1.1542039 0.3362109 0.45962538
## 3      B 2.929028 -0.38319924 -0.8955891 -0.1164828 0.98441377
## 4      B 1.995342 -1.33046592 1.1172876 2.0502761 0.25303846
## 5      B 2.500252 2.01035097 -0.7584035 1.9862169 -1.13537096
## 6      B 2.018308 -0.78242095 0.1125197 -0.6532280 0.01841577
##      PC6      PC7      PC8      PC9      PC10      PC11
## 1 -0.2430058 0.5092015 -1.11423307 0.2840243 0.32463197 -0.3245353
## 2 1.2308248 0.2937434 0.10000461 -0.0668399 0.42612180 0.4564029
## 3 -0.2587872 -0.3303385 0.03599041 0.8734350 0.02222192 0.4208602
## 4 -1.5539634 -0.9692185 -1.31852134 0.6254396 0.05666470 -0.0691646
## 5 0.5940361 0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533
## 6 0.6914453 0.1454026 0.06214539 0.2342454 0.73681239 -0.3671239
##      PC12      PC13      PC14      PC15      PC16      PC17
## 1 0.04981306 -0.19760220 0.1134403 -0.059302558 0.16637723 -0.04286656
## 2 1.19357566 0.01807424 -0.2824292 -0.204858888 -0.07067959 0.03088787
## 3 -0.06687286 0.37435458 0.2585457 -0.330274216 -0.13000189 -0.24616091
## 4 0.97082409 -0.90968379 0.2179117 -0.665825669 0.10213387 -0.10289446
## 5 0.03266208 -0.35547138 -0.1480140 -0.005540503 -0.06495881 0.22273309
## 6 -0.77029743 -0.49542291 -0.2992431 0.049952835 -0.20161083 0.14920422
##      PC18      PC19      PC20      PC21      PC22
## 1 -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## 2 -0.405534243 -0.02886103 -0.05262226 -0.05987170 0.05868642
## 3 0.327711259 0.15937793 -0.13804895 -0.13489743 0.10080029
## 4 0.197085181 0.36251771 -0.40018239 -0.10302093 -0.28821708
## 5 -0.129129156 -0.35877054 0.08515543 -0.08500541 -0.06332008
## 6 -0.002229379 -0.08178568 0.18970936 -0.06872875 0.09669594
##      PC23      PC24      PC25      PC26      PC27
## 1 -0.038971937 0.062212075 0.088438866 0.04872948 -0.007000724
## 2 0.070978613 -0.030822339 -0.016741580 0.04173030 -0.059332996
## 3 0.053909008 0.085484364 0.038277664 -0.04151896 -0.035546410
## 4 0.182045907 0.222848059 -0.115720065 -0.03676948 -0.148171674
## 5 0.043591030 0.008165322 0.002738052 0.05983731 0.046167735
## 6 -0.001458054 -0.031338348 0.042784223 -0.08646068 -0.030944690
##      PC28      PC29      PC30      PC31
## 1 0.05356131 0.015184882 0.015985406 0.001396101
## 2 -0.18696553 0.027011311 -0.000803330 0.008096490
## 3 -0.07653067 -0.014640388 0.010307894 0.009074601
## 4 -0.01711665 -0.047828494 0.023862995 0.000265075
## 5 0.03835364 0.032450800 -0.002312178 -0.002563269
## 6 0.00955434 -0.004403431 0.003869919 -0.002931194
```

```
# Means of scores for all the PC's classified by diagnosis status
tabmeansPC <- aggregate(diag_pca[,2:31],by=list(diagnosis=breast_cancer$diagnosis),mean)
tabmeansPC
```

```
##      diagnosis      PC1      PC2      PC3      PC4      PC5
## 1      B 2.204253 -0.3436398 0.2160542 0.1384470 -0.09800974
## 2      M -3.711879 0.5786765 -0.3638272 -0.2331395 0.16504470
##      PC6      PC7      PC8      PC9      PC10
## 1 0.004373132 0.01691799 0.04905754 0.03377092 -0.01002704
## 2 -0.007364189 -0.02848926 -0.08261104 -0.05686895 0.01688516
##      PC11      PC12      PC13      PC14      PC15
## 1 -0.0007888591 0.006017621 0.003305282 -0.03736471 -0.02453152
## 2 0.0013284090 -0.0101133446 -0.005565970 0.06292076 0.04131016
##      PC16      PC17      PC18      PC19      PC20
## 1 -0.02516699 0.0001112917 0.006103777 -0.01307695 -0.009733891
## 2 0.04238026 -0.0001874111 -0.010278530 0.02202108 0.016391505
##      PC21      PC22      PC23      PC24      PC25
## 1 -0.008359794 -0.006225063 -0.003024993 0.002609428 0.007813479
## 2 0.014077577 0.010482771 0.005093974 -0.004394179 -0.013157604
##      PC26      PC27      PC28      PC29      PC30
## 1 -0.000879209 -0.003967725 -0.001909259 -0.0003418423 -0.0009838392
## 2 0.001480555 0.006681499 0.003215121 0.0005756496 0.0016567480
```

```
tabmeansPC <- tabmeansPC[rev(order(tabmeansPC$diagnosis)),]
tabmeansPC
```

```
##      diagnosis      PC1      PC2      PC3      PC4      PC5
## 2      M -3.711879  0.5786765 -0.3638272 -0.2331395  0.16504470
## 1      B  2.204253 -0.3436398  0.2160542  0.1384470 -0.09800974
##      PC6      PC7      PC8      PC9      PC10
## 2 -0.007364189 -0.02848926 -0.08261104 -0.05686895  0.01688516
## 1  0.004373132  0.01691799  0.04905754  0.03377092 -0.01002704
##      PC11      PC12      PC13      PC14      PC15
## 2  0.0013284090 -0.010133446 -0.005565970  0.06292076  0.04131016
## 1 -0.0007888591  0.006017621  0.003305282 -0.03736471 -0.02453152
##      PC16      PC17      PC18      PC19      PC20
## 2  0.04238026 -0.0001874111 -0.010278530  0.02202108  0.016391505
## 1 -0.02516699  0.0001112917  0.006103777 -0.01307695 -0.009733891
##      PC21      PC22      PC23      PC24      PC25
## 2  0.014077577  0.010482771  0.005093974 -0.004394179 -0.013157604
## 1 -0.008359794 -0.006225063 -0.003024993  0.002609428  0.007813479
##      PC26      PC27      PC28      PC29      PC30
## 2  0.001480555  0.006681499  0.003215121  0.0005756496  0.0016567480
## 1 -0.000879209 -0.003967725 -0.001909259 -0.0003418423 -0.0009838392
```

```
tabfmeans <- t(tabmeansPC[,-1])
tabfmeans
```

```
##      2      1
## PC1 -3.7118786952  2.2042528946
## PC2  0.5786764540 -0.3436397990
## PC3 -0.3638271826  0.2160542373
## PC4 -0.2331394896  0.1384469798
## PC5  0.1650447018 -0.0980097389
## PC6 -0.0073641886  0.0043731316
## PC7 -0.0284892608  0.0169179924
## PC8 -0.0826110415  0.0490575373
## PC9 -0.0568689505  0.0337709174
## PC10 0.0168851623 -0.0100270432
## PC11 0.0013284090 -0.0007888591
## PC12 -0.0101334459  0.0060176205
## PC13 -0.0055659702  0.0033052820
## PC14 0.0629207582 -0.0373647080
## PC15 0.0413101623 -0.0245315249
## PC16 0.0423802589 -0.0251669885
## PC17 -0.0001874111  0.0001112917
## PC18 -0.0102785304  0.0061037771
## PC19 0.0220210837 -0.0130769461
## PC20 0.0163915046 -0.0097338907
## PC21 0.0140775772 -0.0083597937
## PC22 0.0104827709 -0.0062250628
## PC23 0.0050939739 -0.0030249929
## PC24 -0.0043941787  0.0026094282
## PC25 -0.0131576035  0.0078134789
## PC26 0.0014805547 -0.0008792090
## PC27 0.0066814986 -0.0039677247
## PC28 0.0032151208 -0.0019092594
## PC29 0.0005756496 -0.0003418423
## PC30 0.0016567480 -0.0009838392
```

```
colnames(tabfmeans) <- t(as.vector(tabmeansPC[1]))
tabfmeans
```



```
##          M          B
## PC1  -3.7118786952  2.2042528946
## PC2   0.5786764540 -0.3436397990
## PC3  -0.3638271826  0.2160542373
## PC4  -0.2331394896  0.1384469798
## PC5   0.1650447018 -0.0980097389
## PC6  -0.0073641886  0.0043731316
## PC7  -0.0284892608  0.0169179924
## PC8  -0.0826110415  0.0490575373
## PC9  -0.0568689505  0.0337709174
## PC10  0.0168851623 -0.0100270432
## PC11  0.0013284090 -0.0007888591
## PC12 -0.0101334459  0.0060176205
## PC13 -0.0055659702  0.0033052820
## PC14  0.0629207582 -0.0373647080
## PC15  0.0413101623 -0.0245315249
## PC16  0.0423802589 -0.0251669885
## PC17 -0.0001874111  0.0001112917
## PC18 -0.0102785304  0.0061037771
## PC19  0.0220210837 -0.0130769461
## PC20  0.0163915046 -0.0097338907
## PC21  0.0140775772 -0.0083597937
## PC22  0.0104827709 -0.0062250628
## PC23  0.0050939739 -0.0030249929
## PC24 -0.0043941787  0.0026094282
## PC25 -0.0131576035  0.0078134789
## PC26  0.0014805547 -0.0008792090
## PC27  0.0066814986 -0.0039677247
## PC28  0.0032151208 -0.0019092594
## PC29  0.0005756496 -0.0003418423
## PC30  0.0016567480 -0.0009838392
```

```
# Standard deviations of scores for all the PC's classified by diagnosis status
tabsdsPC <- aggregate(diag_pca[,2:31],by=list(breast_cancer$diagnosis),sd)
tabfsds <- t(tabsdsPC[, -1])
colnames(tabfsds) <- t(as.vector(tabsdsPC[1]))
tabfsds
```

```
##          B          M
## PC1  1.63956487  3.02839244
## PC2  2.08691418  2.72966952
## PC3  1.36038677  2.07323861
## PC4  1.39613539  1.39927526
## PC5  1.39777817  1.04807636
## PC6  0.95340249  1.33789147
## PC7  0.95140466  1.05116532
## PC8  0.64932787  1.04212370
## PC9  0.65881989  0.70917409
## PC10 0.57998076  0.71917808
## PC11 0.60269891  0.57186757
## PC12 0.54006502  0.54668527
## PC13 0.51222488  0.51016086
## PC14 0.37926601  0.63294179
## PC15 0.38070917  0.41867516
## PC16 0.26760334  0.36012377
## PC17 0.26627925  0.30856638
## PC18 0.17881651  0.32377631
## PC19 0.17193548  0.30152802
## PC20 0.17202337  0.28613872
## PC21 0.15015083  0.21280261
## PC22 0.15982321  0.19320204
## PC23 0.14579937  0.19476702
## PC24 0.12247334  0.19984615
## PC25 0.11050781  0.16637188
## PC26 0.09806381  0.15950557
## PC27 0.07202620  0.11477556
## PC28 0.06617618  0.10565982
## PC29 0.02588741  0.05609976
## PC30 0.01834069  0.03798219
```

```
t.test(PC1~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC1 by breast_cancer$diagnosis
## t = 26.251, df = 285.72, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  5.472542 6.359721
## sample estimates:
## mean in group B mean in group M
##      2.204253      -3.711879
```

```
t.test(PC2~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC2 by breast_cancer$diagnosis
## t = -4.2387, df = 357.38, p-value = 2.865e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.3502373 -0.4943952
## sample estimates:
## mean in group B mean in group M
##      -0.3436398      0.5786765
```

```
t.test(PC3~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC3 by breast_cancer$diagnosis
## t = 3.6343, df = 320.28, p-value = 0.0003246
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.2659658 0.8937970
## sample estimates:
## mean in group B mean in group M
##      0.2160542      -0.3638272
```

```
t.test(PC4~breast_cancer$diagnosis,data=diag_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC4 by breast_cancer$diagnosis
## t = 3.0652, df = 442.55, p-value = 0.002308
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.1333371 0.6098358
## sample estimates:
## mean in group B mean in group M
##      0.1384470      -0.2331395
```

```
t.test(PC5~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC5 by breast_cancer$diagnosis
## t = -2.5485, df = 537.03, p-value = 0.0111
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.46581747 -0.06029141
## sample estimates:
## mean in group B mean in group M
## -0.09800974 0.16504470
```

```
t.test(PC6~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC6 by breast_cancer$diagnosis
## t = 0.11197, df = 339.17, p-value = 0.9109
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.1944615 0.2179362
## sample estimates:
## mean in group B mean in group M
## 0.004373132 -0.007364189
```

```
t.test(PC7~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC7 by breast_cancer$diagnosis
## t = 0.51587, df = 408.87, p-value = 0.6062
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.1276209 0.2184354
## sample estimates:
## mean in group B mean in group M
## 0.01691799 -0.02848926
```

```
t.test(PC8~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC8 by breast_cancer$diagnosis
## t = 1.6584, df = 309.75, p-value = 0.09825
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.02455572 0.28789287
## sample estimates:
## mean in group B mean in group M
## 0.04905754 -0.08261104
```

```
t.test(PC9~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC9 by breast_cancer$diagnosis
## t = 1.5132, df = 417.67, p-value = 0.131
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.0271048 0.2083845
## sample estimates:
## mean in group B mean in group M
## 0.03377092 -0.05686895
```

```
t.test(PC10~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC10 by breast_cancer$diagnosis
## t = -0.46277, df = 372.52, p-value = 0.6438
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.14126432 0.08743991
## sample estimates:
## mean in group B mean in group M
## -0.01002704 0.01688516
```

```
t.test(PC11~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC11 by breast_cancer$diagnosis
## t = -0.041845, df = 462.01, p-value = 0.9666
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.10154692 0.09731238
## sample estimates:
## mean in group B mean in group M
## -0.0007888591 0.0013284090
```

```
t.test(PC12~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC12 by breast_cancer$diagnosis
## t = 0.34227, df = 439.04, p-value = 0.7323
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.07659212 0.10889425
## sample estimates:
## mean in group B mean in group M
## 0.006017621 -0.010133446
```

```
t.test(PC13~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC13 by breast_cancer$diagnosis
## t = 0.20025, df = 444.77, p-value = 0.8414
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.07819457 0.09593708
## sample estimates:
## mean in group B mean in group M
## 0.003305282 -0.005565970
```

```
t.test(PC14~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC14 by breast_cancer$diagnosis
## t = -2.0945, df = 302.42, p-value = 0.03705
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.194508096 -0.006062836
## sample estimates:
## mean in group B mean in group M
## -0.03736471 0.06292076
```

```
t.test(PC15~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC15 by breast_cancer$diagnosis
## t = -1.8752, df = 410.43, p-value = 0.06147
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.134862771 0.003179396
## sample estimates:
## mean in group B mean in group M
## -0.02453152 0.04131016
```

```
t.test(PC16~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC16 by breast_cancer$diagnosis
## t = -2.37, df = 349.77, p-value = 0.01833
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.12360307 -0.01149143
## sample estimates:
## mean in group B mean in group M
## -0.02516699 0.04238026
```

```
t.test(PC17~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC17 by breast_cancer$diagnosis
## t = 0.011737, df = 393.3, p-value = 0.9906
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.04973747 0.05033487
## sample estimates:
## mean in group B mean in group M
## 0.0001112917 -0.0001874111
```

```
t.test(PC18~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC18 by breast_cancer$diagnosis
## t = 0.67787, df = 288.75, p-value = 0.4984
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.03118389 0.06394850
## sample estimates:
## mean in group B mean in group M
## 0.006103777 -0.010278530
```

```
t.test(PC19~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC19 by breast_cancer$diagnosis
## t = -1.5516, df = 293.85, p-value = 0.1218
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.079616015 0.009419955
## sample estimates:
## mean in group B mean in group M
## -0.01307695 0.02202108
```

```
t.test(PC20~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC20 by breast_cancer$diagnosis
## t = -1.2062, df = 303.02, p-value = 0.2287
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.06874572 0.01649493
## sample estimates:
## mean in group B mean in group M
## -0.009733891 0.016391505
```

```
t.test(PC21~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC21 by breast_cancer$diagnosis
## t = -1.3487, df = 336.76, p-value = 0.1783
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.05516116 0.01028642
## sample estimates:
## mean in group B mean in group M
## -0.008359794 0.014077577
```

```
t.test(PC22~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC22 by breast_cancer$diagnosis
## t = -1.0618, df = 380.13, p-value = 0.289
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.04764831 0.01423264
## sample estimates:
## mean in group B mean in group M
## -0.006225063 0.010482771
```

```
t.test(PC23~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC23 by breast_cancer$diagnosis
## t = -0.52575, df = 351.71, p-value = 0.5994
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.03849078 0.02225285
## sample estimates:
## mean in group B mean in group M
## -0.003024993 0.005093974
```

```
t.test(PC24~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC24 by breast_cancer$diagnosis
## t = 0.4614, df = 306.57, p-value = 0.6448
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.02286480 0.03687201
## sample estimates:
## mean in group B mean in group M
## 0.002609428 -0.004394179
```

```
t.test(PC25~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC25 by breast_cancer$diagnosis
## t = 1.6337, df = 322.91, p-value = 0.1033
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.004282315 0.046224480
## sample estimates:
## mean in group B mean in group M
## 0.007813479 -0.013157604
```

```
t.test(PC26~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC26 by breast_cancer$diagnosis
## t = -0.19467, df = 307.18, p-value = 0.8458
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.02621273 0.02149320
## sample estimates:
## mean in group B mean in group M
## -0.000879209 0.001480555
```

```
t.test(PC27~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC27 by breast_cancer$diagnosis
## t = -1.2162, df = 311.14, p-value = 0.2248
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.027878004 0.006579557
## sample estimates:
## mean in group B mean in group M
## -0.003967725 0.006681499
```

```
t.test(PC28~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC28 by breast_cancer$diagnosis
## t = -0.63596, df = 310.76, p-value = 0.5253
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.02097902 0.01073026
## sample estimates:
## mean in group B mean in group M
## -0.001909259 0.003215121
```

```
t.test(PC29~breast_cancer$diagnosis,data=diag_pca)
```



```
##
## Welch Two Sample t-test
##
## data: PC29 by breast_cancer$diagnosis
## t = -0.22436, df = 265.22, p-value = 0.8226
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.008969119 0.007134135
## sample estimates:
## mean in group B mean in group M
## -0.0003418423 0.0005756496
```

```
t.test(PC30~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC30 by breast_cancer$diagnosis
## t = -0.9487, df = 270.4, p-value = 0.3436
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.008120430 0.002839256
## sample estimates:
## mean in group B mean in group M
## -0.0009838392 0.0016567480
```

```
t.test(PC31~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## Welch Two Sample t-test
##
## data: PC31 by breast_cancer$diagnosis
## t = -0.54256, df = 278.74, p-value = 0.5879
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.002917016 0.001656473
## sample estimates:
## mean in group B mean in group M
## -0.0002348289 0.0003954429
```

```
# F ratio tests
var.test(PC1~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC1 by breast_cancer$diagnosis
## F = 0.29311, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2293890 0.3717204
## sample estimates:
## ratio of variances
## 0.2931115
```

```
var.test(PC2~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC2 by breast_cancer$diagnosis
## F = 0.58451, num df = 356, denom df = 211, p-value = 8.474e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.4574343 0.7412633
## sample estimates:
## ratio of variances
## 0.5845061
```

```
var.test(PC3~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC3 by breast_cancer$diagnosis
## F = 0.43055, num df = 356, denom df = 211, p-value = 2.327e-12
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3369504 0.5460214
## sample estimates:
## ratio of variances
## 0.4305526
```

```
var.test(PC4~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC4 by breast_cancer$diagnosis
## F = 0.99552, num df = 356, denom df = 211, p-value = 0.9625
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.7790915 1.2625024
## sample estimates:
## ratio of variances
## 0.9955172
```

```
var.test(PC5~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC5 by breast_cancer$diagnosis
## F = 1.7787, num df = 356, denom df = 211, p-value = 5.82e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 1.391972 2.255662
## sample estimates:
## ratio of variances
## 1.778651
```

```
var.test(PC6~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC6 by breast_cancer$diagnosis
## F = 0.50782, num df = 356, denom df = 211, p-value = 1.795e-08
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3974207 0.6440124
## sample estimates:
## ratio of variances
## 0.5078212
```

```
var.test(PC7~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC7 by breast_cancer$diagnosis
## F = 0.8192, num df = 356, denom df = 211, p-value = 0.1
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.6411036 1.0388957
## sample estimates:
## ratio of variances
## 0.8191973
```

```
var.test(PC8~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC8 by breast_cancer$diagnosis
## F = 0.38823, num df = 356, denom df = 211, p-value = 3.319e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3038290 0.4923489
## sample estimates:
## ratio of variances
## 0.3882304
```

```
var.test(PC9~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC9 by breast_cancer$diagnosis
## F = 0.86303, num df = 356, denom df = 211, p-value = 0.2243
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.6754099 1.0944883
## sample estimates:
## ratio of variances
## 0.8630336
```

```
var.test(PC10~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC10 by breast_cancer$diagnosis
## F = 0.65036, num df = 356, denom df = 211, p-value = 0.0003698
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.5089722 0.8247793
## sample estimates:
## ratio of variances
##      0.6503607
```

```
var.test(PC11~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC11 by breast_cancer$diagnosis
## F = 1.1107, num df = 356, denom df = 211, p-value = 0.4012
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.8692598 1.4086183
## sample estimates:
## ratio of variances
##      1.110734
```

```
var.test(PC12~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC12 by breast_cancer$diagnosis
## F = 0.97593, num df = 356, denom df = 211, p-value = 0.8346
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.7637603 1.2376584
## sample estimates:
## ratio of variances
##      0.975927
```

```
var.test(PC13~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC13 by breast_cancer$diagnosis
## F = 1.0081, num df = 356, denom df = 211, p-value = 0.956
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.7889451 1.2784699
## sample estimates:
## ratio of variances
##      1.008108
```

```
var.test(PC14~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC14 by breast_cancer$diagnosis
## F = 0.35905, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2809959 0.4553483
## sample estimates:
## ratio of variances
## 0.3590544
```

```
var.test(PC15~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC15 by breast_cancer$diagnosis
## F = 0.82686, num df = 356, denom df = 211, p-value = 0.1169
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.6471009 1.0486142
## sample estimates:
## ratio of variances
## 0.8268605
```

```
var.test(PC16~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC16 by breast_cancer$diagnosis
## F = 0.55218, num df = 356, denom df = 211, p-value = 8.26e-07
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.4321348 0.7002658
## sample estimates:
## ratio of variances
## 0.5521785
```

```
var.test(PC17~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC17 by breast_cancer$diagnosis
## F = 0.74469, num df = 356, denom df = 211, p-value = 0.01494
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.5827968 0.9444106
## sample estimates:
## ratio of variances
## 0.7446933
```

```
var.test(PC18~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC18 by breast_cancer$diagnosis
## F = 0.30502, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2387068 0.3868197
## sample estimates:
## ratio of variances
## 0.3050177
```

```
var.test(PC19~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC19 by breast_cancer$diagnosis
## F = 0.32514, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2544576 0.4123434
## sample estimates:
## ratio of variances
## 0.3251439
```

```
var.test(PC20~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC20 by breast_cancer$diagnosis
## F = 0.36143, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2828534 0.4583583
## sample estimates:
## ratio of variances
## 0.3614279
```

```
var.test(PC21~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC21 by breast_cancer$diagnosis
## F = 0.49785, num df = 356, denom df = 211, p-value = 6.758e-09
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3896201 0.6313716
## sample estimates:
## ratio of variances
## 0.4978535
```

```
var.test(PC22~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC22 by breast_cancer$diagnosis
## F = 0.68432, num df = 356, denom df = 211, p-value = 0.001709
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.5355451 0.8678402
## sample estimates:
## ratio of variances
## 0.6843154
```

```
var.test(PC23~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC23 by breast_cancer$diagnosis
## F = 0.56038, num df = 356, denom df = 211, p-value = 1.542e-06
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.4385511 0.7106634
## sample estimates:
## ratio of variances
## 0.5603772
```

```
var.test(PC24~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC24 by breast_cancer$diagnosis
## F = 0.37557, num df = 356, denom df = 211, p-value = 3.495e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2939215 0.4762939
## sample estimates:
## ratio of variances
## 0.3755706
```

```
var.test(PC25~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC25 by breast_cancer$diagnosis
## F = 0.44119, num df = 356, denom df = 211, p-value = 9.824e-12
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3452756 0.5595122
## sample estimates:
## ratio of variances
## 0.4411905
```

```
var.test(PC26~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC26 by breast_cancer$diagnosis
## F = 0.37798, num df = 356, denom df = 211, p-value = 5.423e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2958050 0.4793461
## sample estimates:
## ratio of variances
## 0.3779774
```

```
var.test(PC27~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC27 by breast_cancer$diagnosis
## F = 0.39381, num df = 356, denom df = 211, p-value = 8.544e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3081924 0.4994196
## sample estimates:
## ratio of variances
## 0.3938058
```

```
var.test(PC28~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC28 by breast_cancer$diagnosis
## F = 0.39227, num df = 356, denom df = 211, p-value = 6.601e-15
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.3069894 0.4974701
## sample estimates:
## ratio of variances
## 0.3922686
```

```
var.test(PC29~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC29 by breast_cancer$diagnosis
## F = 0.21294, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.1666460 0.2700465
## sample estimates:
## ratio of variances
## 0.2129389
```

```
var.test(PC30~breast_cancer$diagnosis,data=diag_pca)
```



```
##
## F test to compare two variances
##
## data: PC30 by breast_cancer$diagnosis
## F = 0.23317, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.1824782 0.2957024
## sample estimates:
## ratio of variances
## 0.2331693
```

```
var.test(PC31~breast_cancer$diagnosis,data=diag_pca)
```

```
##
## F test to compare two variances
##
## data: PC31 by breast_cancer$diagnosis
## F = 0.26577, num df = 356, denom df = 211, p-value < 2.2e-16
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
## 0.2079951 0.3370519
## sample estimates:
## ratio of variances
## 0.2657746
```

```
# Levene's tests (one-sided)
library(car)
(LTPC1 <- leveneTest(PC1~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1  62.132 1.654e-14 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC1_1sided <- LTPC1[[3]][1]/2)
```

```
## [1] 8.268824e-15
```

```
(LTPC2 <- leveneTest(PC2~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1  18.786 1.73e-05 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC2_1sided=LTPC2[[3]][1]/2)
```

```
## [1] 8.651441e-06
```

```
(LTPC3 <- leveneTest(PC3~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1   27.65 2.063e-07 ***
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC3_1sided <- LTPC3[[3]][1]/2)
```

```
## [1] 1.031266e-07
```

```
(LTPC4 <- leveneTest(PC4~breast_cancer$diagnosis,data=diag_pca))
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value Pr(>F)
## group 1    2e-04 0.989
##      567
```

```
(p_PC4_1sided <- LTPC4[[3]][1]/2)
```

```
## [1] 0.4944984
```

```
(LTPC5 <- leveneTest(PC5~breast_cancer$diagnosis,data=diag_pca))
```

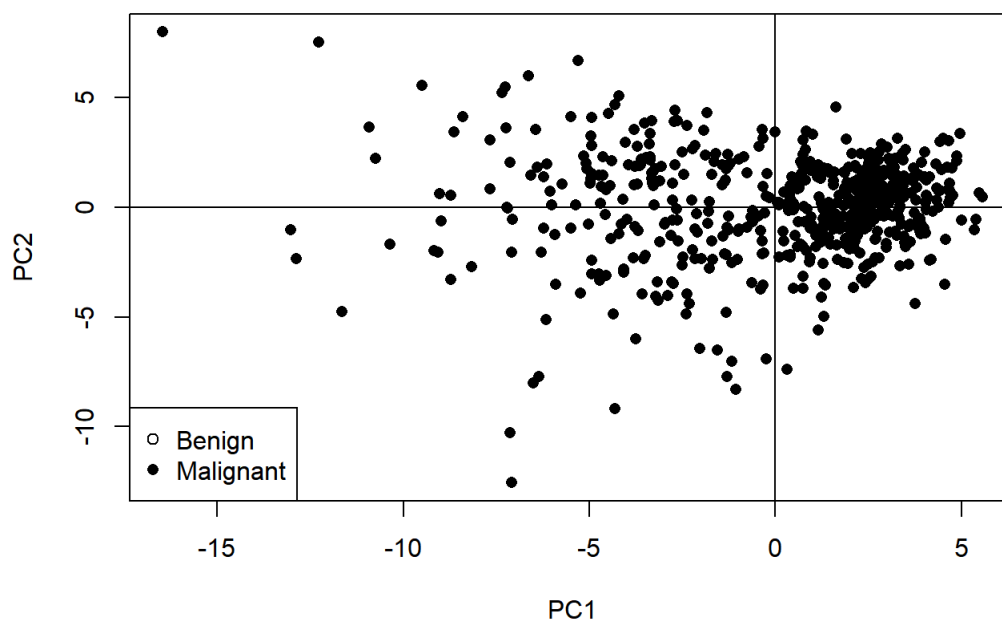
```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value  Pr(>F)
## group 1  6.8535 0.009083 **
##      567
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(p_PC5_1sided <- LTPC5[[3]][1]/2)
```

```
## [1] 0.004541533
```

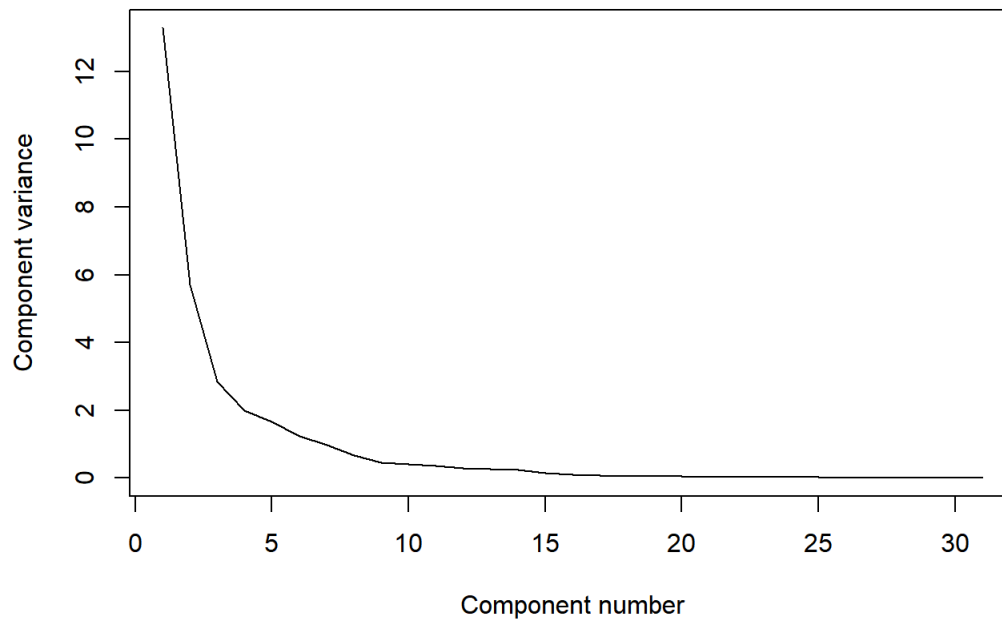
```
# Plotting the scores for the first and second components
plot(diag_pca$PC1, diag_pca$PC2, pch=ifelse(diag_pca$diagnosis == "S", 1, 16), xlab="PC1", ylab="PC2", main="569
entries against values for PC1 & PC2")
abline(h=0)
abline(v=0)
legend("bottomleft", legend=c("Benign", "Malignant"), pch=c(1, 16))
```

**569 entries against values for PC1 & PC2**



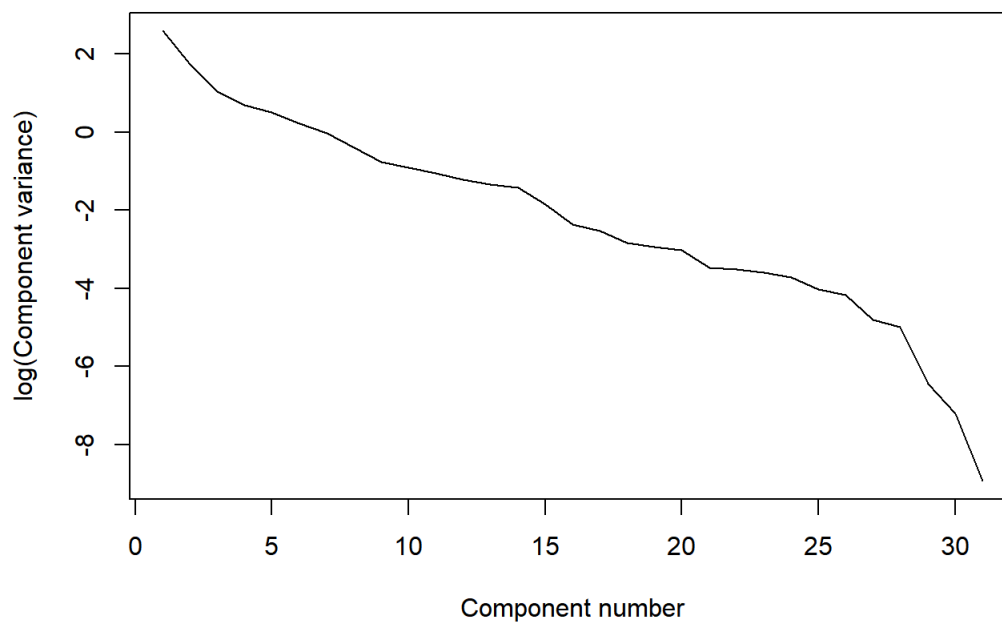
```
plot(eigen_breast_cancer, xlab = "Component number", ylab = "Component variance", type = "l", main = "Scree
diagram")
```

**Scree diagram**



```
plot(log(eigen_breast_cancer), xlab = "Component number", ylab = "log(Component variance)", type="l", main = "Log(eigenvalue) diagram")
```

**Log(eigenvalue) diagram**



```
print(summary(breast_cancer_pca))
```

```
## Importance of components:
##          PC1      PC2      PC3      PC4      PC5      PC6
## Standard deviation  3.6453 2.3868 1.68386 1.40761 1.28406 1.11116
## Proportion of Variance 0.4286 0.1838 0.09146 0.06391 0.05319 0.03983
## Cumulative Proportion 0.4286 0.6124 0.70388 0.76779 0.82098 0.86081
##          PC7      PC8      PC9      PC10      PC11      PC12
## Standard deviation  0.98908 0.81961 0.67882 0.6349 0.59089 0.54212
## Proportion of Variance 0.03156 0.02167 0.01486 0.0130 0.01126 0.00948
## Cumulative Proportion 0.89237 0.91404 0.92890 0.9419 0.95317 0.96265
##          PC13      PC14      PC15      PC16      PC17      PC18
## Standard deviation  0.51103 0.49125 0.39620 0.30680 0.28251 0.2430
## Proportion of Variance 0.00842 0.00778 0.00506 0.00304 0.00257 0.0019
## Cumulative Proportion 0.97107 0.97886 0.98392 0.98696 0.98953 0.9914
##          PC19      PC20      PC21      PC22      PC23      PC24
## Standard deviation  0.2293 0.22163 0.1763 0.17304 0.16562 0.15572
## Proportion of Variance 0.0017 0.00158 0.0010 0.00097 0.00088 0.00078
## Cumulative Proportion 0.9931 0.99472 0.9957 0.99669 0.99757 0.99835
##          PC25      PC26      PC27      PC28      PC29      PC30
## Standard deviation  0.13431 0.1244 0.09040 0.08305 0.03987 0.02736
## Proportion of Variance 0.00058 0.0005 0.00026 0.00022 0.00005 0.00002
## Cumulative Proportion 0.99893 0.9994 0.99970 0.99992 0.99997 1.00000
##          PC31
## Standard deviation  0.01153
## Proportion of Variance 0.00000
## Cumulative Proportion 1.00000
```

```
#View(breast_cancer_pca)
diag(cov(breast_cancer_pca$x))
```

```
##          PC1      PC2      PC3      PC4      PC5
## 1.328806e+01 5.696805e+00 2.835395e+00 1.981357e+00 1.648815e+00
##          PC6      PC7      PC8      PC9      PC10
## 1.234673e+00 9.782732e-01 6.717530e-01 4.607924e-01 4.031331e-01
##          PC11      PC12      PC13      PC14      PC15
## 3.491550e-01 2.938904e-01 2.611469e-01 2.413302e-01 1.569736e-01
##          PC16      PC17      PC18      PC19      PC20
## 9.412853e-02 7.980995e-02 5.904627e-02 5.259119e-02 4.912193e-02
##          PC21      PC22      PC23      PC24      PC25
## 3.107078e-02 2.994121e-02 2.743052e-02 2.424902e-02 1.803936e-02
##          PC26      PC27      PC28      PC29      PC30
## 1.547973e-02 8.171699e-03 6.898103e-03 1.589338e-03 7.483761e-04
##          PC31
## 1.330402e-04
```

```
xlim <- range(breast_cancer_pca$x[,1])
head(breast_cancer_pca$x[,1])
```

```
## [1] 2.501946 1.467439 2.929028 1.995342 2.500252 2.018308
```

```
head(breast_cancer_pca$x)
```

```
##          PC1          PC2          PC3          PC4          PC5          PC6
## [1,] 2.501946 -0.09694805 -0.4489597 2.3341176 0.69771548 -0.2430058
## [2,] 1.467439 -1.68630059 1.1542039 0.3362109 0.45962538 1.2308248
## [3,] 2.929028 -0.38319924 -0.8955891 -0.1164828 0.98441377 -0.2587872
## [4,] 1.995342 -1.33046592 1.1172876 2.0502761 0.25303846 -1.5539634
## [5,] 2.500252 2.01035097 -0.7584035 1.9862169 -1.13537096 0.5940361
## [6,] 2.018308 -0.78242095 0.1125197 -0.6532280 0.01841577 0.6914453
##          PC7          PC8          PC9          PC10          PC11          PC12
## [1,] 0.5092015 -1.11423307 0.2840243 0.32463197 -0.3245353 0.04981306
## [2,] 0.2937434 0.10000461 -0.0668399 0.42612180 0.4564029 1.19357566
## [3,] -0.3303385 0.03599041 0.8734350 0.02222192 0.4208602 -0.06687286
## [4,] -0.9692185 -1.31852134 0.6254396 0.05666470 -0.0691646 0.97082409
## [5,] 0.1198201 -0.48279704 -0.2727816 -0.29439485 -0.3577533 0.03266208
## [6,] 0.1454026 0.06214539 0.2342454 0.73681239 -0.3671239 -0.77029743
##          PC13          PC14          PC15          PC16          PC17
## [1,] -0.19760220 0.1134403 -0.059302558 0.16637723 -0.04286656
## [2,] 0.01807424 -0.2824292 -0.204858888 -0.07067959 0.03088787
## [3,] 0.37435458 0.2585457 -0.330274216 -0.13000189 -0.24616091
## [4,] -0.90968379 0.2179117 -0.665825669 0.10213387 -0.10289446
## [5,] -0.35547138 -0.1480140 -0.005540503 -0.06495881 0.22273309
## [6,] -0.49542291 -0.2992431 0.049952835 -0.20161083 0.14920422
##          PC18          PC19          PC20          PC21          PC22
## [1,] -0.104542766 -0.03484189 -0.09691187 -0.02846306 -0.00673628
## [2,] -0.405534243 -0.02886103 -0.05262226 -0.05987170 0.05868642
## [3,] 0.327711259 0.15937793 -0.13804895 -0.13489743 0.10080029
## [4,] 0.197085181 0.36251771 -0.40018239 -0.10302093 -0.28821708
## [5,] -0.129129156 -0.35877054 0.08515543 -0.08500541 -0.06332008
## [6,] -0.002229379 -0.08178568 0.18970936 -0.06872875 0.09669594
##          PC23          PC24          PC25          PC26          PC27
## [1,] -0.038971937 0.062212075 0.088438866 0.04872948 -0.007000724
## [2,] 0.070978613 -0.030822339 -0.016741580 0.04173030 -0.059332996
## [3,] 0.053909008 0.085484364 0.038277664 -0.04151896 -0.035546410
## [4,] 0.182045907 0.222848059 -0.115720065 -0.03676948 -0.148171674
## [5,] 0.043591030 0.008165322 0.002738052 0.05983731 0.046167735
## [6,] -0.001458054 -0.031338348 0.042784223 -0.08646068 -0.030944690
##          PC28          PC29          PC30          PC31
## [1,] 0.05356131 0.015184882 0.015985406 0.001396101
## [2,] -0.18696553 0.027011311 -0.000803330 0.008096490
## [3,] -0.07653067 -0.014640388 0.010307894 0.009074601
## [4,] -0.01711665 -0.047828494 0.023862995 0.000265075
## [5,] 0.03835364 0.032450800 -0.002312178 -0.002563269
## [6,] 0.00955434 -0.004403431 0.003869919 -0.002931194
```

```
plot(breast_cancer_pca$x,xlim=xlim,ylim=xlim)
```

