STAT547_LAB3

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STAT547: Lab3 Plotting Multivariate Data

Objectives

- To learn how to produce plots of multivariate data, both static and interactive.
- Practice describing the patterns and relationships observed in the multivariate plots.

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.0.5
```

```
library(GGally)
```

```
## Warning: package 'GGally' was built under R version 4.0.5
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

Question_1

Music Clips Data

The music clips data is posted in music-plusnew-sub.csv. The data file has five quantitative variables contining audio information from 62 songs. The first two columns (Artist, Type) describe the artist and type of music. The raw data come from a time series for the sound produced by each music clip (track). For each time series the variance of amplitude, average amplitude, maximum amplitude, and two additional variables calculated from the spectral decomposition of the time series are calculated. The Type variable classifies the tracks as either Rock, Classical or New Wave, and there are 5 tracks that are not identified. Read the data into a data frame, indicating that the row names are in column 1 of the data file and that column is not a variable. The stringAsFactors=FALSE option prevents the first column from being converted to a factor.

Obtain information on the dimensions of the data frame. Also list the column names. List the first six columns of data.

```
setwd("D:/lecture_notes/STAT_575_Multivariate_Data_Analysis_BZ/Labs/Lab_3")
music <- read.csv("music-plusnew-sub.csv", row.names = 1, stringsAsFactors = FALSE)
colnames(music)
```

```
## [1] "Artist" "Type"   "LVar"   "LAve"   "LMax"   "LFEner" "LFreq"
```

```
dim(music)
```

```
## [1] 62  7
```

```
str(music)
```

```
## 'data.frame':    62 obs. of  7 variables:
##  $ Artist: chr  "Abba" "Abba" "Abba" "Abba" ...
##  $ Type  : chr  "Rock" "Rock" "Rock" "Rock" ...
##  $ LVar  : num  17600756 9543021 9049482 7557437 6282286 ...
##  $ LAve  : num  -90 -75.8 -98.1 -90.5 -89 ...
##  $ LMax  : int  29921 27626 26372 28898 27940 25531 14699 8928 22962 15517 ...
##  $ LFEner: num  106 103 102 102 100 ...
##  $ LFreq : num  59.6 58.5 124.6 48.8 74 ...
```

Compute summary statistics

```
summary(music)
```

```
##     Artist              Type                LVar                LAve
##  Length:62          Length:62          Min.   :   293608   Min.   :-98.063
##  Class :character   Class :character   1st Qu.:  2844213   1st Qu.: -6.253
##  Mode  :character   Mode  :character   Median :  8210359   Median : -5.662
##                                        Mean   : 19951792   Mean   : -7.807
##                                        3rd Qu.: 24547475   3rd Qu.:  1.962
##                                        Max.   :129472199   Max.   :216.232
##       LMax           LFEner           LFreq
##  Min.   : 2985   Min.   : 83.88   Min.   : 41.41
##  1st Qu.:16200   1st Qu.:101.69   1st Qu.: 99.18
##  Median :24431   Median :104.35   Median :175.29
##  Mean   :22486   Mean   :104.03   Mean   :231.39
##  3rd Qu.:29919   3rd Qu.:108.15   3rd Qu.:315.12
##  Max.   :32766   Max.   :114.00   Max.   :877.77
```

Compute a table of counts for each type of music. [Hint: Generate frequency table]

```
table(music$Type)
```

```
##
## Classical  New wave      Rock
##        24         3        30
```

Compute a table of counts for each artist. [Hint: Generate frequency table]

```
table(music$Artist)
```

```
##
##      Abba   Beatles Beethoven      Eels      Enya    Mozart   Vivaldi
##        10        10         8        10         3         6        10
```

Exercise 1 Music clips data:

Exercise 1

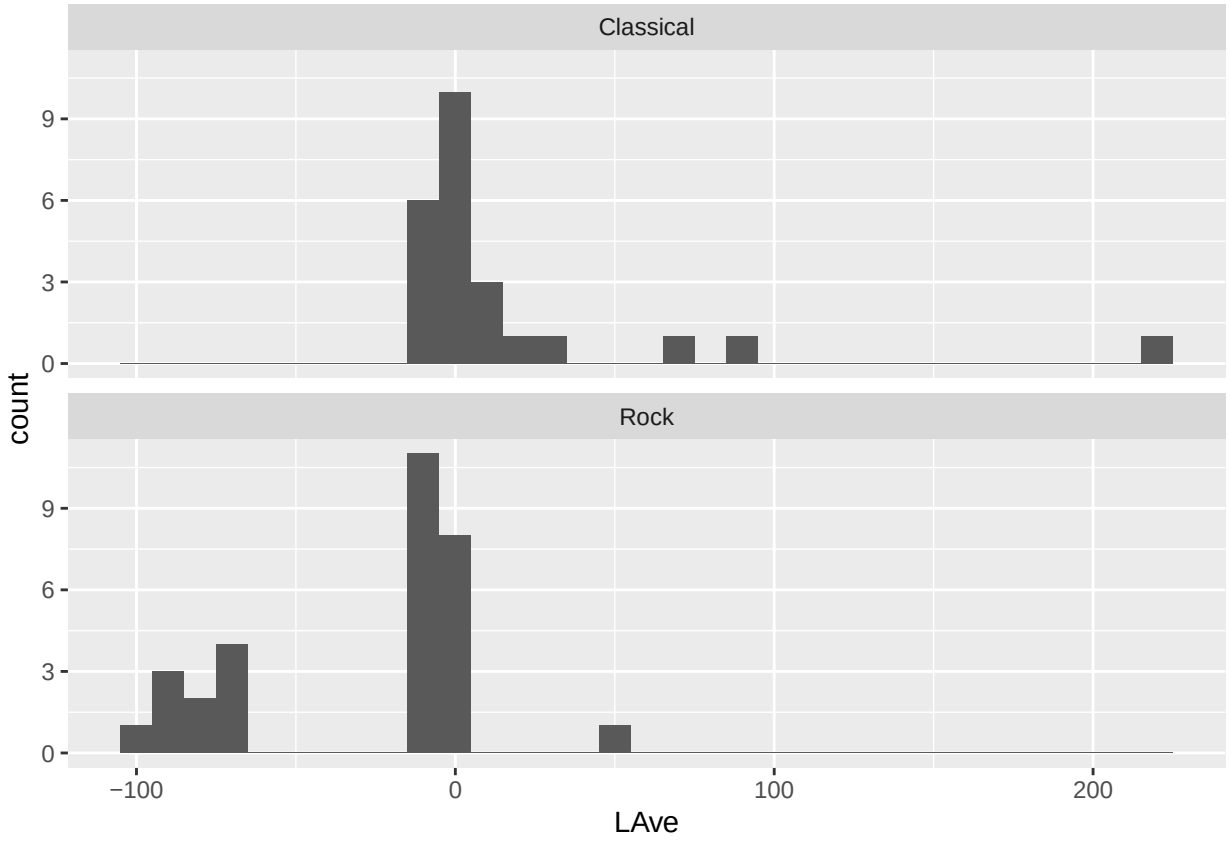
This exercise uses the qplot function in the ggplot2 package to make a panel of histograms and a scatterplot. First select a subset of the data that contains only classical and rock music.

a). For classical and rock music make histograms for the avergae amplitude variable (LAve) facetted by Type. Set the binwidth to units of 10. How do the distributions of average amplitude values differ between classical and rock music?

```
library(ggplot2)
library(GGally)
music.sub <- subset(music, Type == "Rock" | Type == "Classical")
```

```
# Histogram
# Short version
#qplot(LAve, data = music.sub, geom = "histogram", binwidth = 10) +
  #facet_wrap(~ Type, ncol = 1)

# Full version
ggplot(music.sub, aes(x = LAve)) +
  geom_histogram(binwidth = 10) +
  facet_wrap(~ Type, ncol = 1)
```

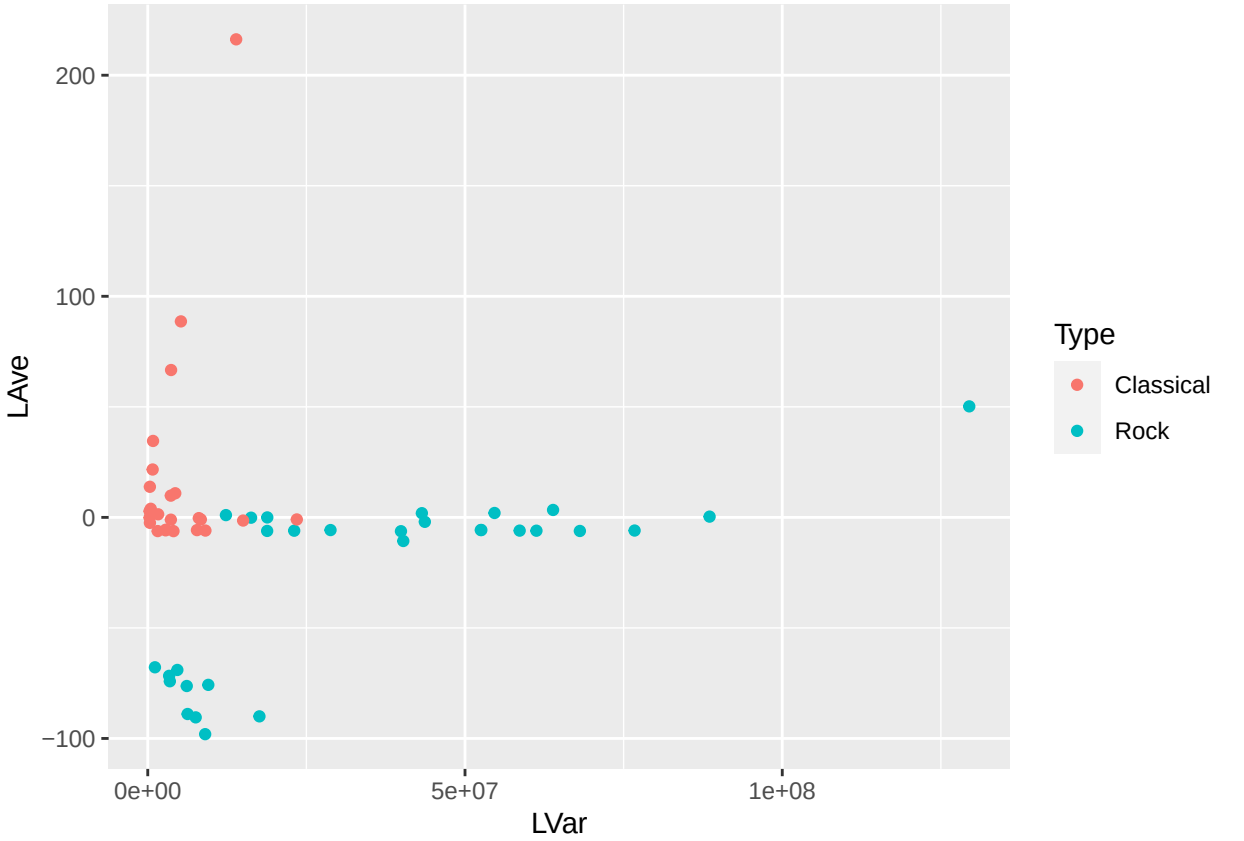


(a) classical music average amplitude values are unimodal , more spread out (more variation) and right skewed. Rock music is bimodal, less spread out and left skewed.

b).

Make a scatterplot of LVar vs LAve, with points colored by the type of music. Describe differences between the patterns of the points on the plot corresponding to Rock and Classical music.

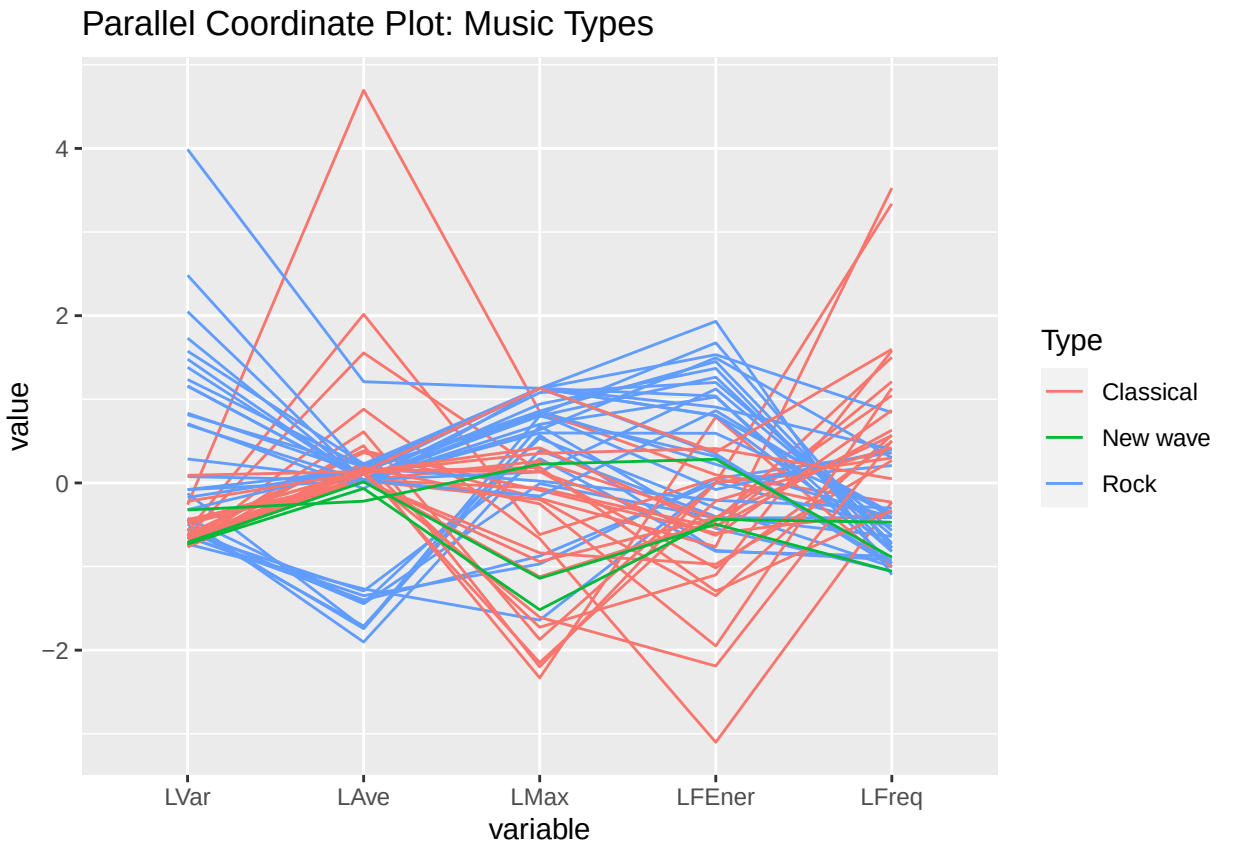
```
ggplot(music.sub, aes(x=LVar, y = LAve, color=Type)) +
  geom_point()
```



(b) Classical music large variance and small average, while Rock music has small variance and large average. Rock music is divided in two groups.

(c)

```
music.sub2 <- subset(music, Type == "Rock" | Type == "Classical" | Type=="New wave")
ggparcoord(music.sub2, columns=3:7, groupColumn="Type",
           title="Parallel Coordinate Plot: Music Types")
```



Rock: large variance, max and energy, lower frequency. Rock music can be sub-divided in two groups (types).

Classical : large average, frequency but small variance, max and energy.

New wave : small average, variance, max, energy and frequeny

Bodyfat data

The body fat data bodyfat.csv contains various measurements on 14 variables for 252 typical American males.

Obtain information on the dimensions of the data frame. Also list the column names. List the first six columns of data.

```
bodyfat <- read.csv("bodyfat.csv")
dim(bodyfat)
```

```
## [1] 252  14
```

```
colnames(bodyfat)
```

```
##  [1] "Percent.Body.Fat" "Ageyrs"           "Weightlbs"        "Heightinches"
##  [5] "NeckCircm"        "ChestCircm"       "AbdomenCircm"     "HipCircm"
##  [9] "ThighCircm"       "KneeCircm"        "AnkleCircm"       "BicepsCircm"
## [13] "ForearmCircm"     "WristCircm"
```

```
str(bodyfat)
```

```
## 'data.frame':    252 obs. of  14 variables:
##  $ Percent.Body.Fat: num  12.3 6.1 25.3 10.4 28.7 20.9 19.2 12.4 4.1 11.7 ...
##  $ Ageyrs          : int  23 22 22 26 24 24 26 25 25 23 ...
```

```
##  $ Weightlbs       : num  154 173 154 185 184 ...
##  $ Heightinches    : num  67.8 72.2 66.2 72.2 71.2 ...
##  $ NeckCircm       : num  36.2 38.5 34 37.4 34.4 39 36.4 37.8 38.1 42.1 ...
##  $ ChestCircm      : num  93.1 93.6 95.8 101.8 97.3 ...
##  $ AbdomenCircm    : num  85.2 83 87.9 86.4 100 94.4 90.7 88.5 82.5 88.6 ...
##  $ HipCircm        : num  94.5 98.7 99.2 101.2 101.9 ...
##  $ ThighCircm      : num  59 58.7 59.6 60.1 63.2 66 58.4 60 62.9 63.1 ...
##  $ KneeCircm       : num  37.3 37.3 38.9 37.3 42.2 42 38.3 39.4 38.3 41.7 ...
##  $ AnkleCircm      : num  21.9 23.4 24 22.8 24 25.6 22.9 23.2 23.8 25 ...
##  $ BicepsCircm     : num  32 30.5 28.8 32.4 32.2 35.7 31.9 30.5 35.9 35.6 ...
##  $ ForearmCircm    : num  27.4 28.9 25.2 29.4 27.7 30.6 27.8 29 31.1 30 ...
##  $ WristCircm      : num  17.1 18.2 16.6 18.2 17.7 18.8 17.7 18.8 18.2 19.2 ...
```

```
head(bodyfat)
```

```
##   Percent.Body.Fat Ageyrs Weightlbs Heightinches NeckCircm ChestCircm
## 1             12.3     23    154.25        67.75      36.2       93.1
## 2              6.1     22    173.25        72.25      38.5       93.6
## 3             25.3     22    154.00        66.25      34.0       95.8
## 4             10.4     26    184.75        72.25      37.4      101.8
## 5             28.7     24    184.25        71.25      34.4       97.3
## 6             20.9     24    210.25        74.75      39.0      104.5
##   AbdomenCircm HipCircm ThighCircm KneeCircm AnkleCircm BicepsCircm
## 1         85.2     94.5       59.0      37.3       21.9        32.0
## 2         83.0     98.7       58.7      37.3       23.4        30.5
## 3         87.9     99.2       59.6      38.9       24.0        28.8
## 4         86.4    101.2       60.1      37.3       22.8        32.4
## 5        100.0    101.9       63.2      42.2       24.0        32.2
## 6         94.4    107.8       66.0      42.0       25.6        35.7
##   ForearmCircm WristCircm
## 1         27.4       17.1
## 2         28.9       18.2
## 3         25.2       16.6
## 4         29.4       18.2
## 5         27.7       17.7
## 6         30.6       18.8
```

Compute summary statistics

```
summary(bodyfat)
```

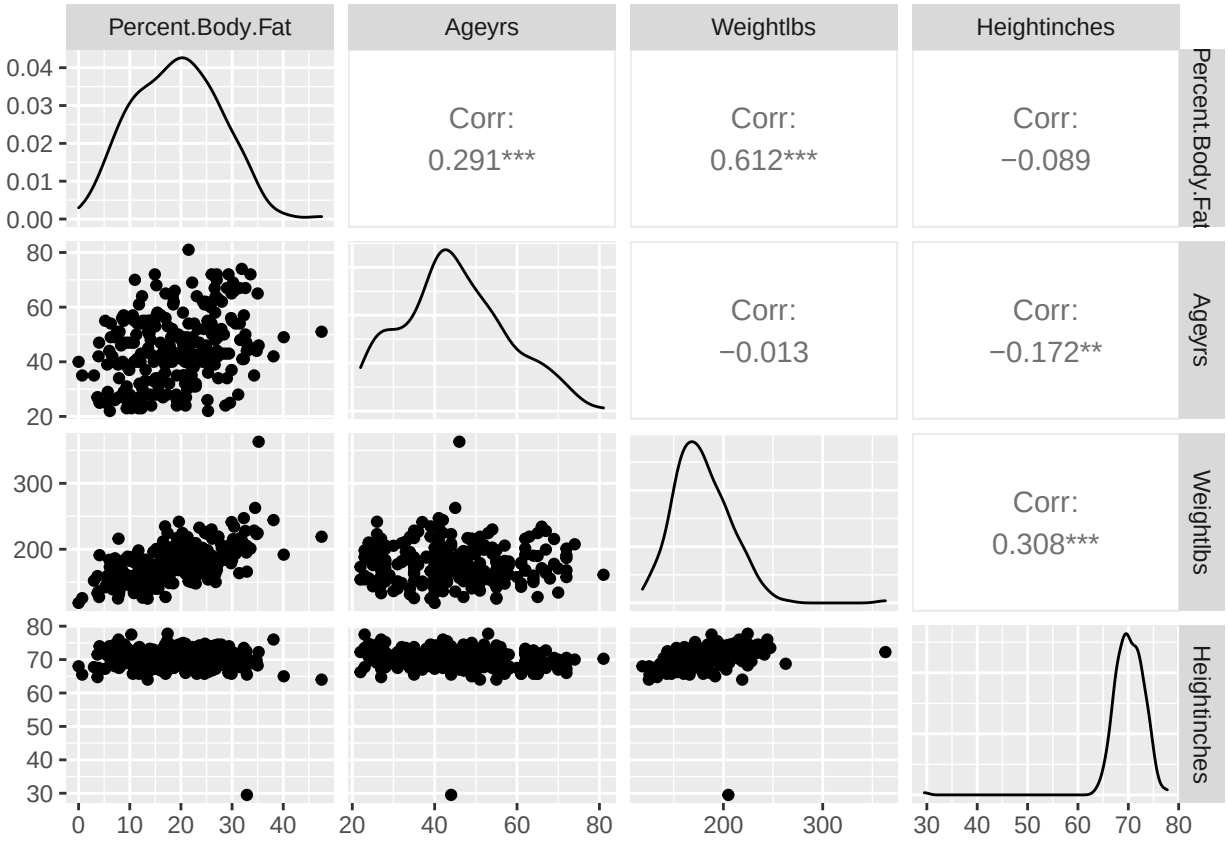
```
##  Percent.Body.Fat     Ageyrs        Weightlbs      Heightinches
##  Min.   : 0.00    Min.   :22.00   Min.   :118.5   Min.   :29.50
##  1st Qu.:12.47    1st Qu.:35.75   1st Qu.:159.0   1st Qu.:68.25
##  Median :19.20    Median :43.00   Median :176.5   Median :70.00
##  Mean   :19.15    Mean   :44.88   Mean   :178.9   Mean   :70.15
##  3rd Qu.:25.30    3rd Qu.:54.00   3rd Qu.:197.0   3rd Qu.:72.25
##  Max.   :47.50    Max.   :81.00   Max.   :363.1   Max.   :77.75
##    NeckCircm       ChestCircm      AbdomenCircm       HipCircm
##  Min.   :31.10   Min.   : 79.30   Min.   : 69.40   Min.   : 85.0
##  1st Qu.:36.40   1st Qu.: 94.35   1st Qu.: 84.58   1st Qu.: 95.5
##  Median :38.00   Median : 99.65   Median : 90.95   Median : 99.3
##  Mean   :37.99   Mean   :100.82   Mean   : 92.56   Mean   : 99.9
##  3rd Qu.:39.42   3rd Qu.:105.38   3rd Qu.: 99.33   3rd Qu.:103.5
##  Max.   :51.20   Max.   :136.20   Max.   :148.10   Max.   :147.7
##    ThighCircm      KneeCircm       AnkleCircm    BicepsCircm     ForearmCircm
```

```
##  Min.   :47.20   Min.   :33.00   Min.   :19.1   Min.   :24.80   Min.   :21.00
##  1st Qu.:56.00   1st Qu.:36.98   1st Qu.:22.0   1st Qu.:30.20   1st Qu.:27.30
##  Median :59.00   Median :38.50   Median :22.8   Median :32.05   Median :28.70
##  Mean   :59.41   Mean   :38.59   Mean   :23.1   Mean   :32.27   Mean   :28.66
##  3rd Qu.:62.35   3rd Qu.:39.92   3rd Qu.:24.0   3rd Qu.:34.33   3rd Qu.:30.00
##  Max.   :87.30   Max.   :49.10   Max.   :33.9   Max.   :45.00   Max.   :34.90
##    WristCircm
##  Min.   :15.80
##  1st Qu.:17.60
##  Median :18.30
##  Mean   :18.23
##  3rd Qu.:18.80
##  Max.   :21.40
```

Exercise 2 Body fat data: Using GGally.

1. Make a scatterplot matrix of the first four variables, % Body Fat, Age, Weight and Height. There's a problem with the data. What is it?

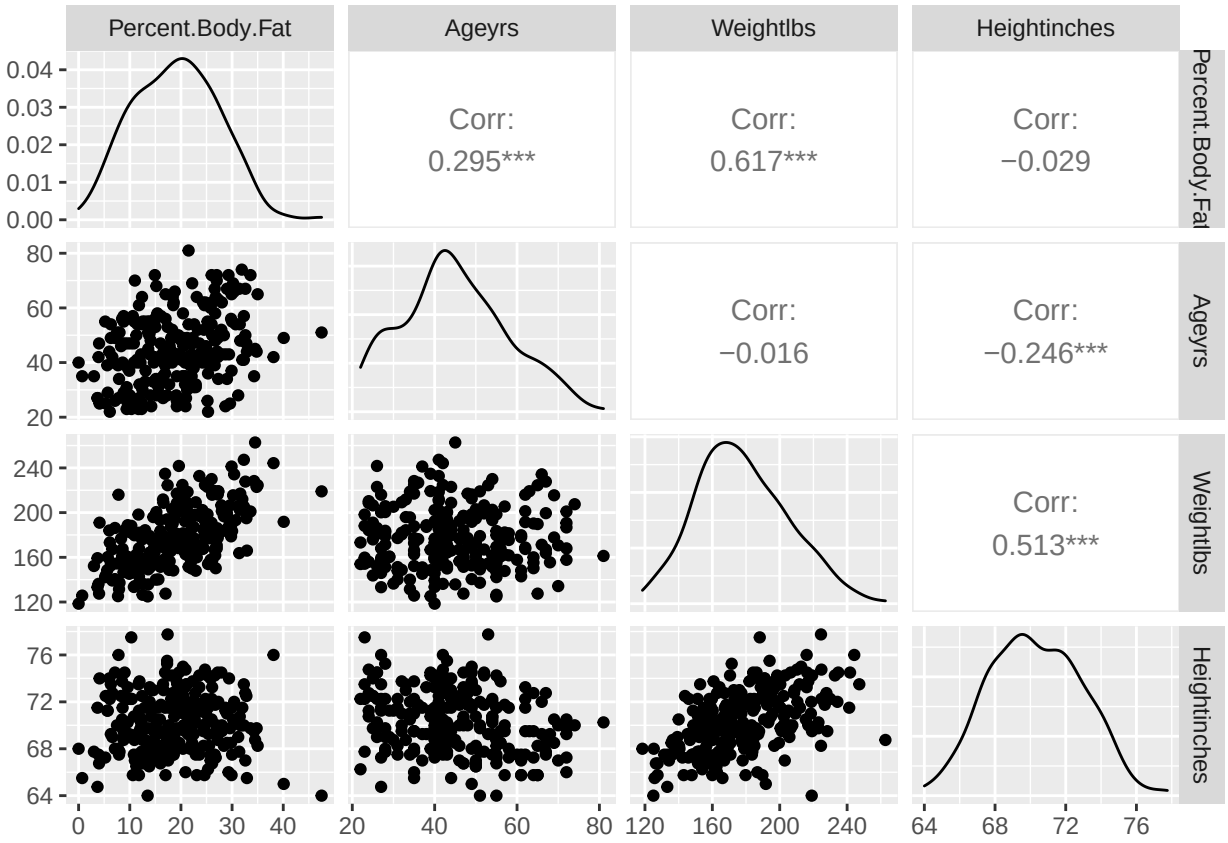
```
ggpairs(bodyfat, columns = 1:4)
```



There 2 outliers

2. Fix the problem with the data and remake the scatterplot matrix. Describe the association between the variables.

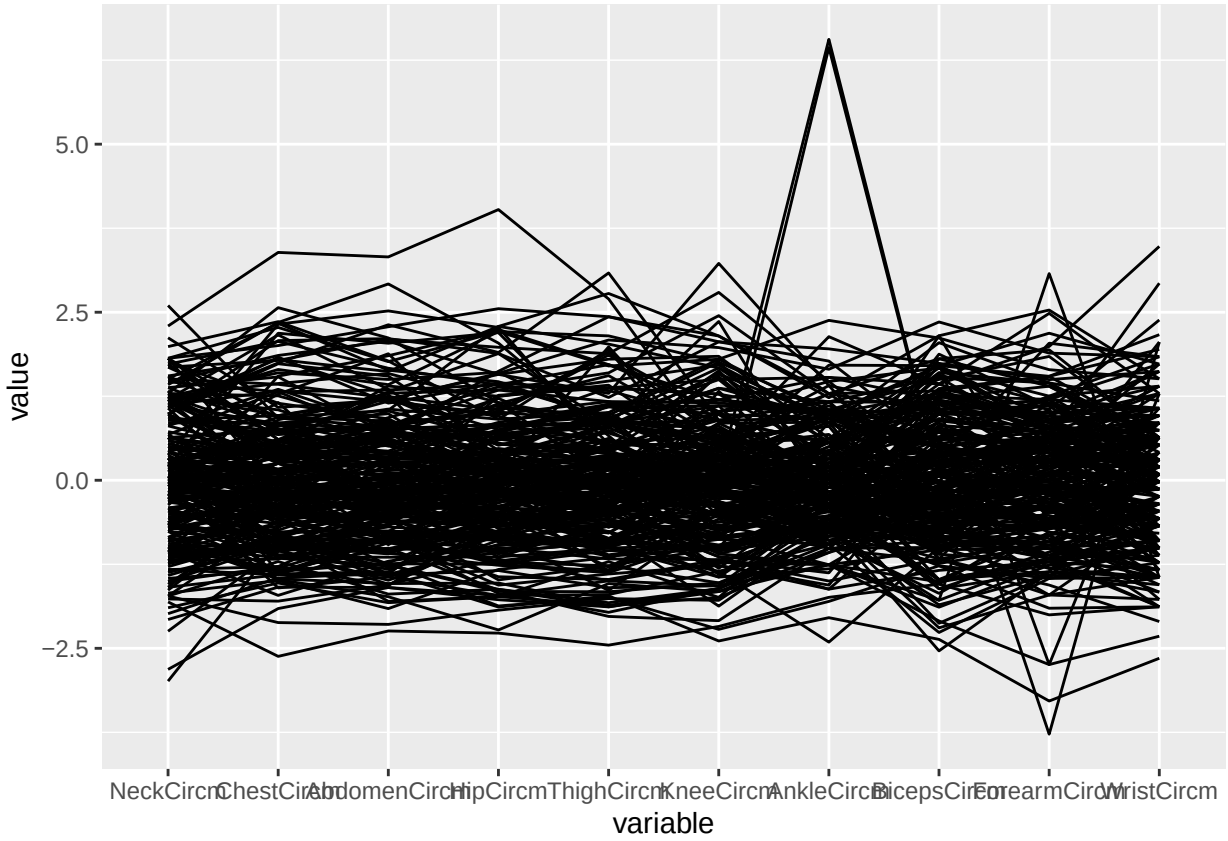
```
bf.sub <- subset(bodyfat, Heightinches > 60 & Weightlbs < 300)
ggpairs(bf.sub, columns = 1:4)
```



There is moderete positive relationship between weight and body fat, weight and height. There no obvious relationship between the other variables.

3. Make a parallel coordinate plot of the last 10 variables, the circumference variables. There are some outliers in these measurements. Explain the ones that you see.

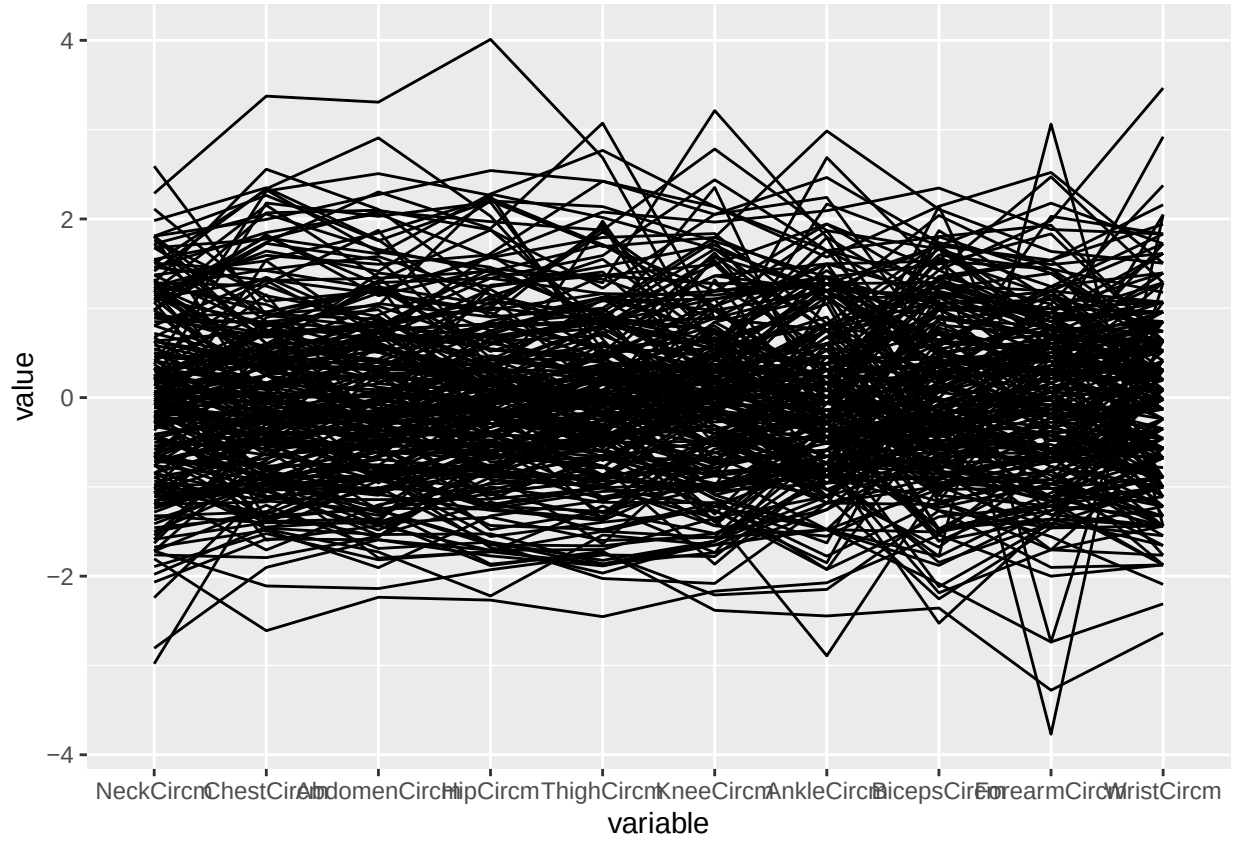
```
# Parallel coordinate plot
ggparcoord(bf.sub, 5:14)
```



There are two outliers which have large angle circumference

4. Remove the outliers and remake the parallel coordinate plot. Describe the structure of the data.

```
bf.sub2 <- subset(bf.sub, AnkleCircm < 33)
ggparcoord(bf.sub2, 5:14)
```



All variables bounce aronnd their centers and there

Question_3

PISA Data

Mathematics test scores for 15 year olds. Only the USA measurements are examined. These are the scores for the different types of math skills.

```
pisamath <- read.csv("pisamathmeans.csv")
dim(pisamath)
```

```
## [1] 10294     8
```

```
head(pisamath)
```

```
##   Gender      acc      acq      acs      acu      ape      apf      api
## 1 Female 432.0844 456.6989 444.5474 405.7564 441.1201 439.0949 415.8825
## 2 Female 422.0362 450.5453 457.3999 457.8673 448.2084 432.0065 411.5984
## 3 Female 527.0369 563.4912 554.9229 489.3364 516.9107 538.8768 519.5591
## 4 Female 436.2128 487.6227 449.4548 489.9595 492.6079 461.2946 435.4339
## 5   Male 631.1030 572.9942 563.8028 580.7836 627.6757 643.2544 580.1604
## 6 Female 424.3730 443.8464 390.5671 424.5287 456.9326 411.7542 441.9769
```

```
colnames(pisamath)
```

```
## [1] "Gender" "acc"    "acq"    "acs"    "acu"    "ape"    "apf"    "api"
```

```
str(pisamath)
```

```
## 'data.frame':    10294 obs. of  8 variables:
##  $ Gender: chr  "Female" "Female" "Female" "Female" ...
##  $ acc   : num  432 422 527 436 631 ...
##  $ acq   : num  457 451 563 488 573 ...
##  $ acs   : num  445 457 555 449 564 ...
##  $ acu   : num  406 458 489 490 581 ...
##  $ ape   : num  441 448 517 493 628 ...
##  $ apf   : num  439 432 539 461 643 ...
##  $ api   : num  416 412 520 435 580 ...
```

Compute summary statistics

```
summary(pisamath)
```

```
##     Gender               acc             acq             acs       
##  Length:10294       Min.   :162.8   Min.   :115.1   Min.   :115.8  
##  Class :character   1st Qu.:426.1   1st Qu.:412.2   1st Qu.:399.9  
##  Mode  :character   Median :494.2   Median :483.6   Median :467.5  
##                     Mean   :497.3   Mean   :483.0   Mean   :471.1  
##                     3rd Qu.:566.1   3rd Qu.:552.5   3rd Qu.:537.8  
##                     Max.   :827.2   Max.   :792.6   Max.   :809.7  
##                     NA's   :4978    NA's   :4978    NA's   :4978   
##       acu             ape             apf              api        
##  Min.   :165.2   Min.   :153.7   Min.   : 93.87   Min.   : 97.76  
##  1st Qu.:431.9   1st Qu.:420.8   1st Qu.:411.89   1st Qu.:428.03  
##  Median :495.6   Median :486.4   Median :480.07   Median :497.05  
##  Mean   :497.6   Mean   :487.5   Mean   :484.73   Mean   :498.71  
##  3rd Qu.:559.9   3rd Qu.:551.8   3rd Qu.:553.87   3rd Qu.:566.00  
##  Max.   :785.0   Max.   :778.7   Max.   :841.34   Max.   :837.44  
##  NA's   :4978    NA's   :4978    NA's   :4978     NA's   :4978
```

Exercise 3 PISA Maths scores

1. How many missing values for variable acc? Remove the missing values in the data.

```
summary(pisamath$acc)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's 
##   162.8   426.1   494.2   497.3   566.1   827.2    4978
```

There are 4978 missing values

Remove the missing values in the data.

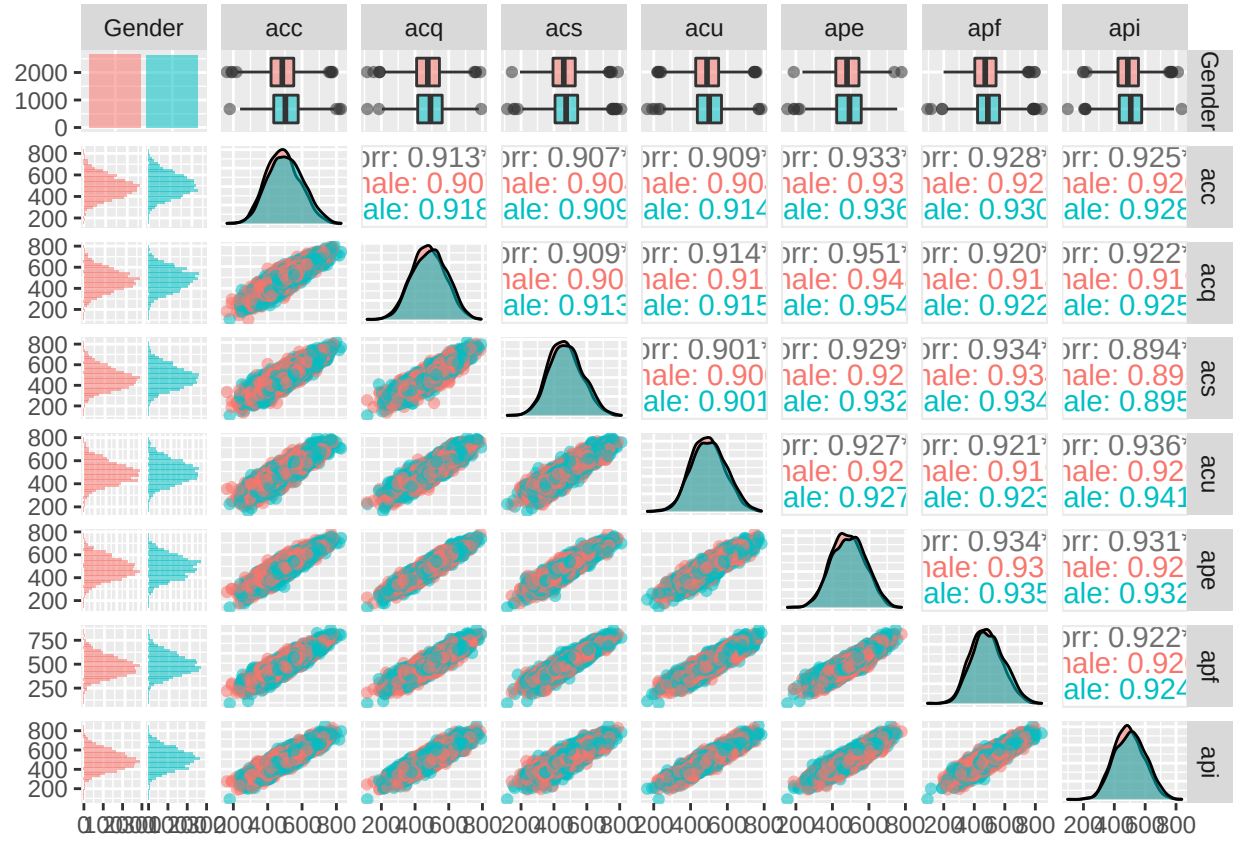
```
# Scatterplot matrix
pisamath2 <- subset(pisamath, !is.na(acc))
summary(pisamath2$acc)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##   162.8   426.1   494.2   497.3   566.1   827.2
```

2. Make a scatterplot matrix of the variables, with points coloured by Gender. Describe the association between the variables.

```
# Scatterplot matrix
ggpairs(pisamath2, mapping = aes(color = Gender, alpha = 0.5))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Both genders have similar distributions for all variables All variables have a strong positive linear relationship between all pairs of 7 test scores.