Data Exploration and Visualisation with R *

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R and Data Mining Course

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*Chapter 3: Data Exploration, in *R and Data Mining: Examples and Case Studies*. http://www.rdatamining.com/docs/RDataMining-book.pdf

Contents

Data Exploration and Visualisation with R

Data Exploration and Visualisation

- Summary and stats
- Various charts like pie charts and histograms
- Exploration of multiple variables
- Level plot, contour plot and 3D plot
- Saving charts into files

Quiz: What's the Name of This Flower?

The Iris Dataset

The `iris` dataset [Frank and Asuncion, 2010] consists of 50 samples from each of three classes of iris flowers. There are five attributes in the dataset:

- sepal length in cm,
- sepal width in cm,
- petal length in cm,
- petal width in cm, and
- class: Iris Setosa, Iris Versicolour, and Iris Virginica.

Detailed desription of the dataset can be found at the UCI Machine Learning Repository [†].

[†] `https://archive.ics.uci.edu/ml/datasets/Iris`

Contents

Size and Variables Names of Data

```
# number of rows
nrow(iris)
## [1] 150

# number of columns
ncol(iris)
## [1] 5

# dimensionality
dim(iris)
## [1] 150   5

# column names
names(iris)
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Wid...
## [5] "Species"
```

Structure of Data

Below we have a look at the structure of the dataset with `str()`.

```
str(iris)
## 'data.frame': 150 obs. of  5 variables:
##  $ Sepal.Length: num  5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...
##  $ Sepal.Width : num  3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1...
##  $ Petal.Length: num  1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1...
##  $ Petal.Width : num  0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0...
##  $ Species     : Factor w/ 3 levels "setosa","versicolor",....
```

- 150 observations (records, or rows) and 5 variables (or columns)
- The first four variables are numeric.
- The last one, `Species`, is categoric (called "factor" in R) and has three levels of values.

Attributes of Data

```
attributes(iris)
```

```
## $names
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Wid...
## [5] "Species"
##
## $class
## [1] "data.frame"
##
## $row.names
##   [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  ...
##  [16]  16  17  18  19  20  21  22  23  24  25  26  27  28  ...
##  [31]  31  32  33  34  35  36  37  38  39  40  41  42  43  ...
##  [46]  46  47  48  49  50  51  52  53  54  55  56  57  58  ...
##  [61]  61  62  63  64  65  66  67  68  69  70  71  72  73  ...
##  [76]  76  77  78  79  80  81  82  83  84  85  86  87  88  ...
##  [91]  91  92  93  94  95  96  97  98  99 100 101 102 103 1...
## [106] 106 107 108 109 110 111 112 113 114 115 116 117 118 1...
## [121] 121 122 123 124 125 126 127 128 129 130 131 132 133 1...
## [136] 136 137 138 139 140 141 142 143 144 145 146 147 148 1...
```

First/Last Rows of Data

```
iris[1:3, ]
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa

head(iris, 3)
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa

tail(iris, 3)
##     Sepal.Length Sepal.Width Petal.Length Petal.Width   Spe...
## 148          6.5         3.0          5.2         2.0 virgi...
## 149          6.2         3.4          5.4         2.3 virgi...
## 150          5.9         3.0          5.1         1.8 virgi...
```

A Single Column

The first 10 values of `Sepal.Length`

```
iris[1:10, "Sepal.Length"]
##  [1] 5.1 4.9 4.7 4.6 5.0 5.4 4.6 5.0 4.4 4.9

iris$Sepal.Length[1:10]
##  [1] 5.1 4.9 4.7 4.6 5.0 5.4 4.6 5.0 4.4 4.9
```

Contents

Summary of Data

Function `summary()`

- numeric variables: minimum, maximum, mean, median, and the first (25%) and third (75%) quartiles
- categorical variables (i.e., factors): frequency of every level

```
summary(iris)
##   Sepal.Length    Sepal.Width     Petal.Length    Petal.Wid...
##  Min.   :4.300   Min.   :2.000   Min.   :1.000   Min.   :0....
##  1st Qu.:5.100   1st Qu.:2.800   1st Qu.:1.600   1st Qu.:0....
##  Median :5.800   Median :3.000   Median :4.350   Median :1....
##  Mean   :5.843   Mean   :3.057   Mean   :3.758   Mean   :1....
##  3rd Qu.:6.400   3rd Qu.:3.300   3rd Qu.:5.100   3rd Qu.:1....
##  Max.   :7.900   Max.   :4.400   Max.   :6.900   Max.   :2....
##        Species
##  setosa    :50
##  versicolor:50
##  virginica :50
##
##
##
```

```r
library(Hmisc)
# describe(iris) # check all columns
describe(iris[, c(1, 5)])  # check columns 1 and 5
```

```
## iris[, c(1, 5)]
##
##  2  Variables      150  Observations
## ---------------------------------------------------------...
## Sepal.Length
##        n  missing distinct     Info     Mean      Gmd      ...
##      150        0       35    0.998    5.843   0.9462    4....
##      .10      .25      .50      .75      .90      .95
##    4.800    5.100    5.800    6.400    6.900    7.255
##
## lowest : 4.3 4.4 4.5 4.6 4.7, highest: 7.3 7.4 7.6 7.7 7.9
## ---------------------------------------------------------...
## Species
##        n  missing distinct
##      150        0        3
##
## Value          setosa versicolor  virginica
## Frequency          50         50         50
## Proportion      0.333      0.333      0.333
## ---------------------------------------------------------...
```

Mean, Median, Range and Quartiles

- Mean, median and range: `mean()`, `median()`, `range()`
- Quartiles and percentiles: `quantile()`

```
range(iris$Sepal.Length)
## [1] 4.3 7.9

quantile(iris$Sepal.Length)
##   0%  25%  50%  75% 100%
##  4.3  5.1  5.8  6.4  7.9

quantile(iris$Sepal.Length, c(0.1, 0.3, 0.65))
##  10%  30%  65%
## 4.80 5.27 6.20
```

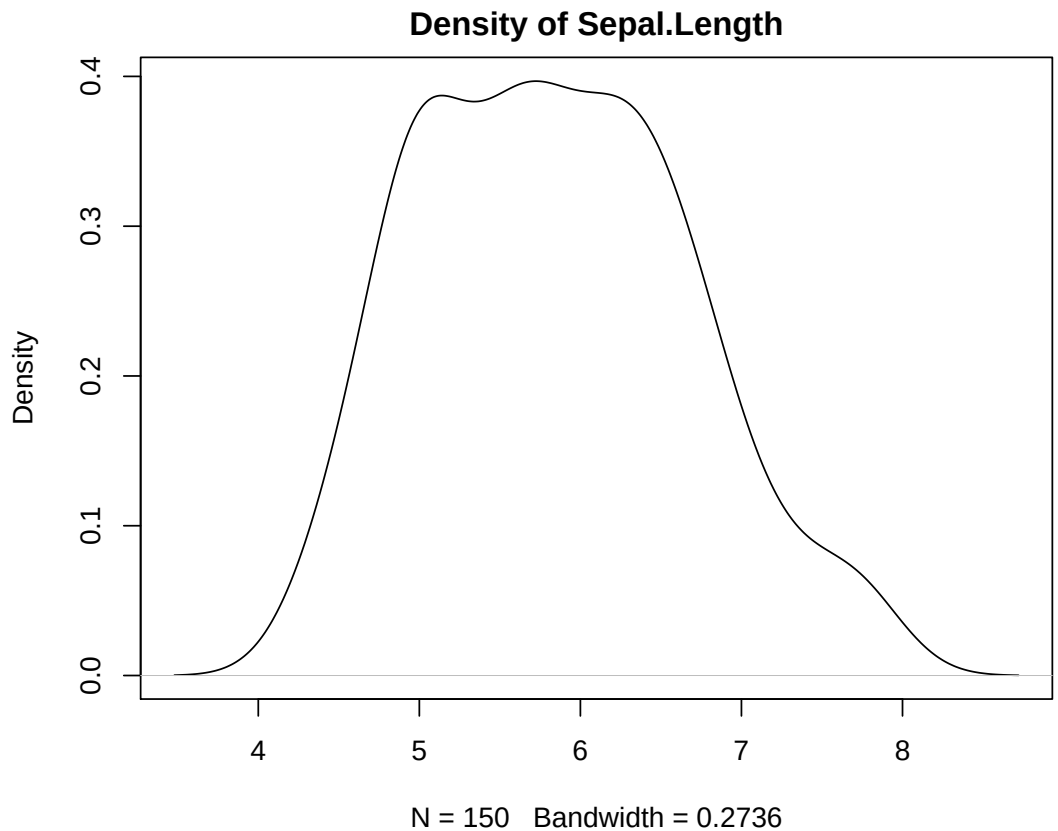
Variance and Histogram

```
var(iris$Sepal.Length)
## [1] 0.6856935

hist(iris$Sepal.Length)
```

Density

```
library(magrittr) ## for pipe operations
iris$Sepal.Length %>% density() %>%
  plot(main='Density of Sepal.Length')
```

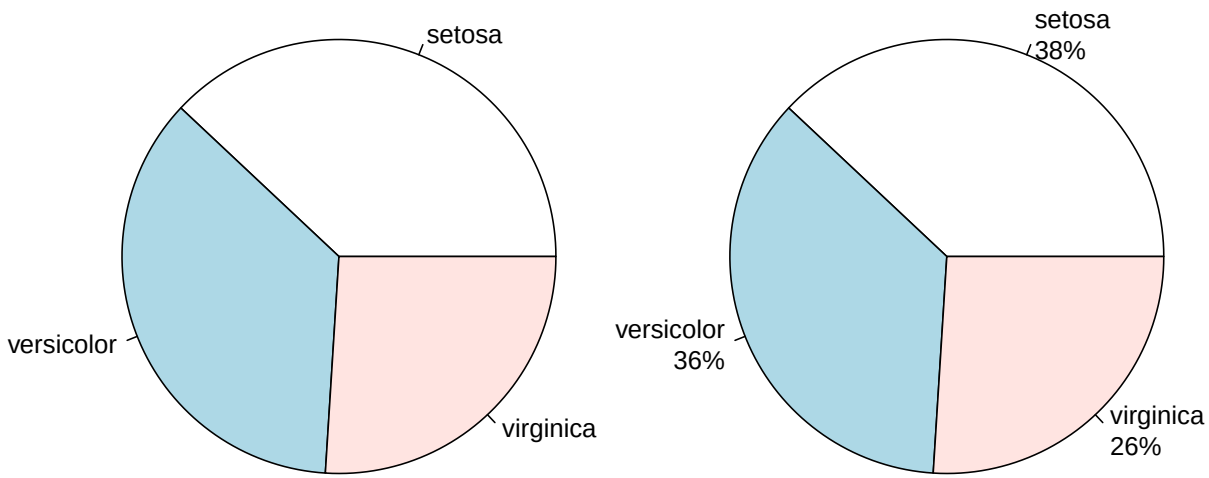


Pie Chart

Frequency of factors: `table()`

```
library(dplyr)
iris2 <- iris %>% sample_n(50)
iris2$Species %>% table() %>% pie()

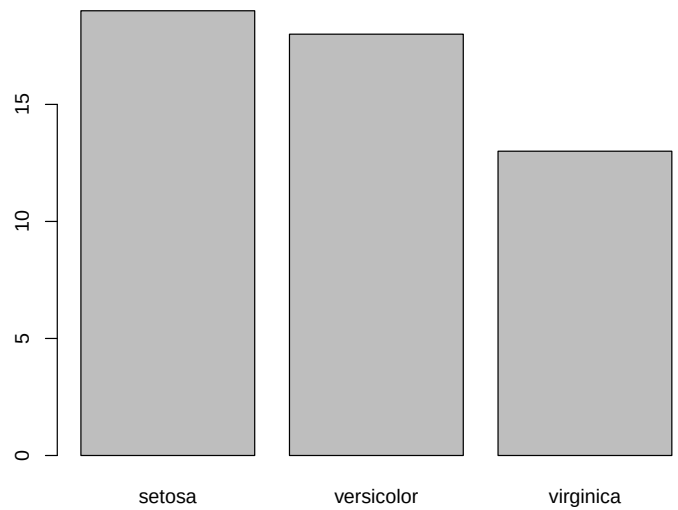
# add percentages
tab <- iris2$Species %>% table()
precentages <- tab %>% prop.table() %>% round(3) * 100
txt <- paste0(names(tab), '\n', precentages, '%')
pie(tab, labels=txt)
```

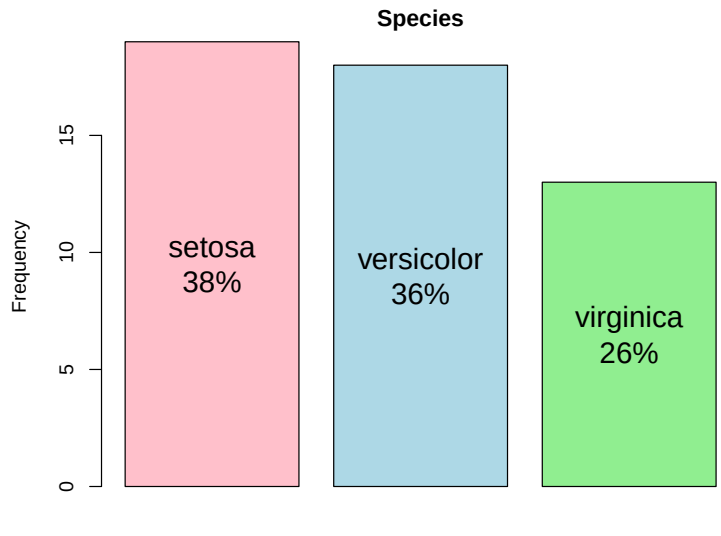


Bar Chart

```
iris2$Species %>% table() %>% barplot()

# add colors and percentages
bb <- iris2$Species %>% table() %>%
      barplot(axisnames=F, main='Species', ylab='Frequency',
              col=c('pink', 'lightblue', 'lightgreen'))
text(bb, tab/2, labels=txt, cex=1.5)
```





Contents

Correlation

Covariance and correlation: cov() and cor()

```
cov(iris$Sepal.Length, iris$Petal.Length)
## [1] 1.274315

cor(iris$Sepal.Length, iris$Petal.Length)
## [1] 0.8717538

cov(iris[, 1:4])
##              Sepal.Length Sepal.Width Petal.Length Petal.Width
## Sepal.Length    0.6856935  -0.0424340    1.2743154   0.5162707
## Sepal.Width    -0.0424340   0.1899794   -0.3296564  -0.1216394
## Petal.Length    1.2743154  -0.3296564    3.1162779   1.2956094
## Petal.Width     0.5162707  -0.1216394    1.2956094   0.5810063

# cor(iris[,1:4])
```

Aggreation

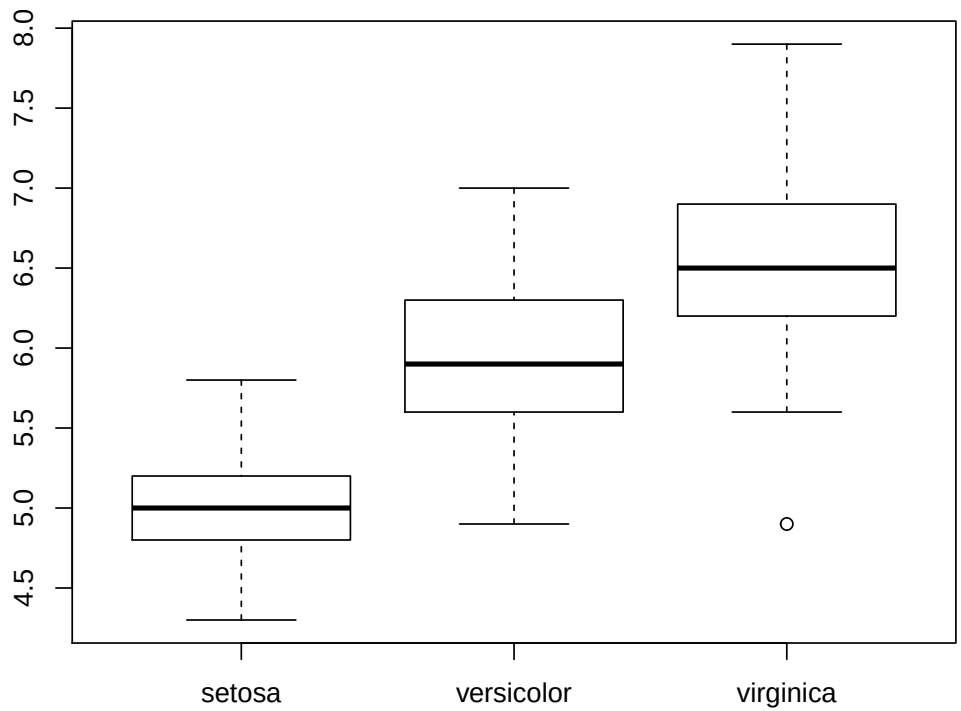
Stats of `Sepal.Length` for every `Species` with `aggregate()`

```
aggregate(Sepal.Length ~ Species, summary, data = iris)
##      Species Sepal.Length.Min. Sepal.Length.1st Qu.
## 1     setosa             4.300                4.800
## 2 versicolor             4.900                5.600
## 3  virginica             4.900                6.225
##   Sepal.Length.Median Sepal.Length.Mean Sepal.Length.3rd Qu.
## 1               5.000              5.006                5.200
## 2               5.900              5.936                6.300
## 3               6.500              6.588                6.900
##   Sepal.Length.Max.
## 1             5.800
## 2             7.000
## 3             7.900
```

Boxplot

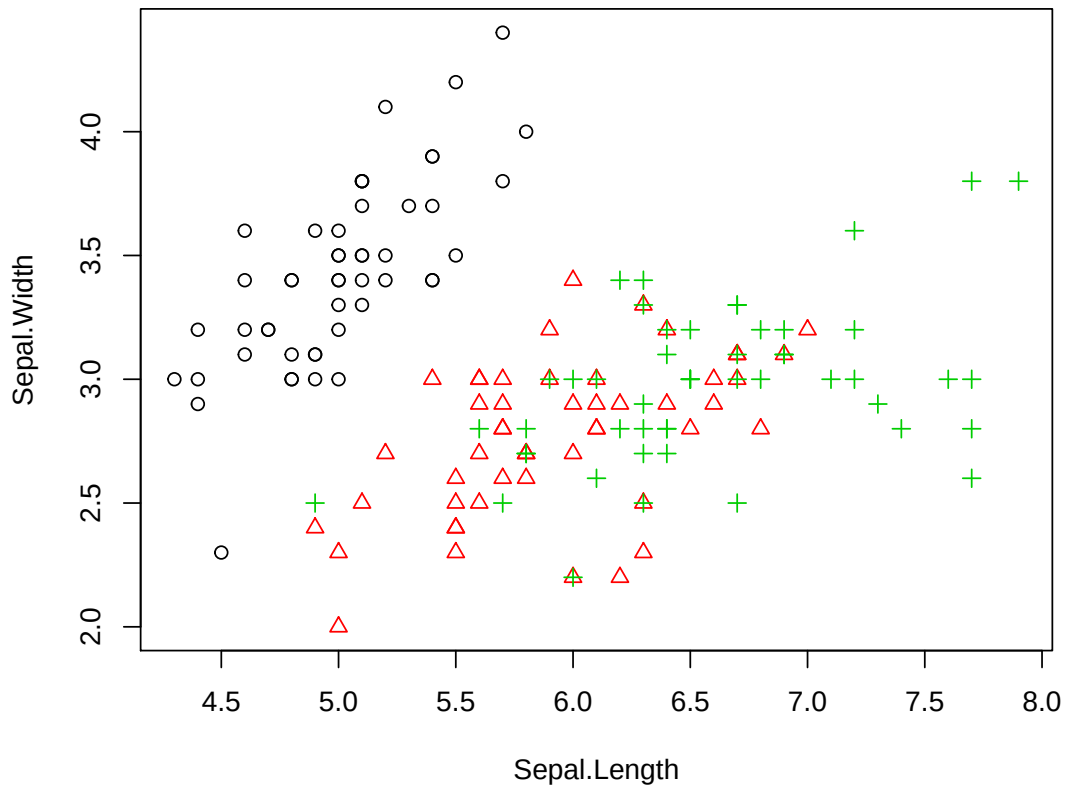
- The bar in the middle is median.
- The box shows the interquartile range (IQR), i.e., range between the 75% and 25% observation.

```
boxplot(Sepal.Length ~ Species, data = iris)
```



Scatter Plot

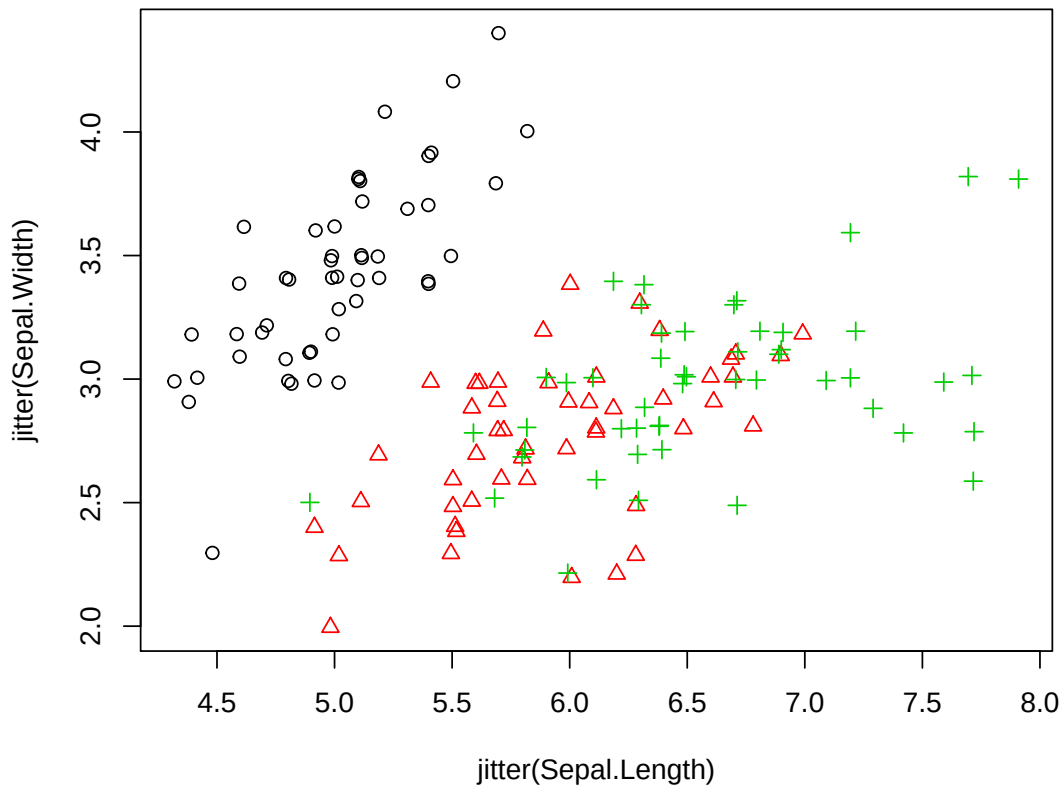
```
with(iris, plot(Sepal.Length, Sepal.Width, col = Species,
                pch = as.numeric(Species)))
```



Scatter Plot with Jitter

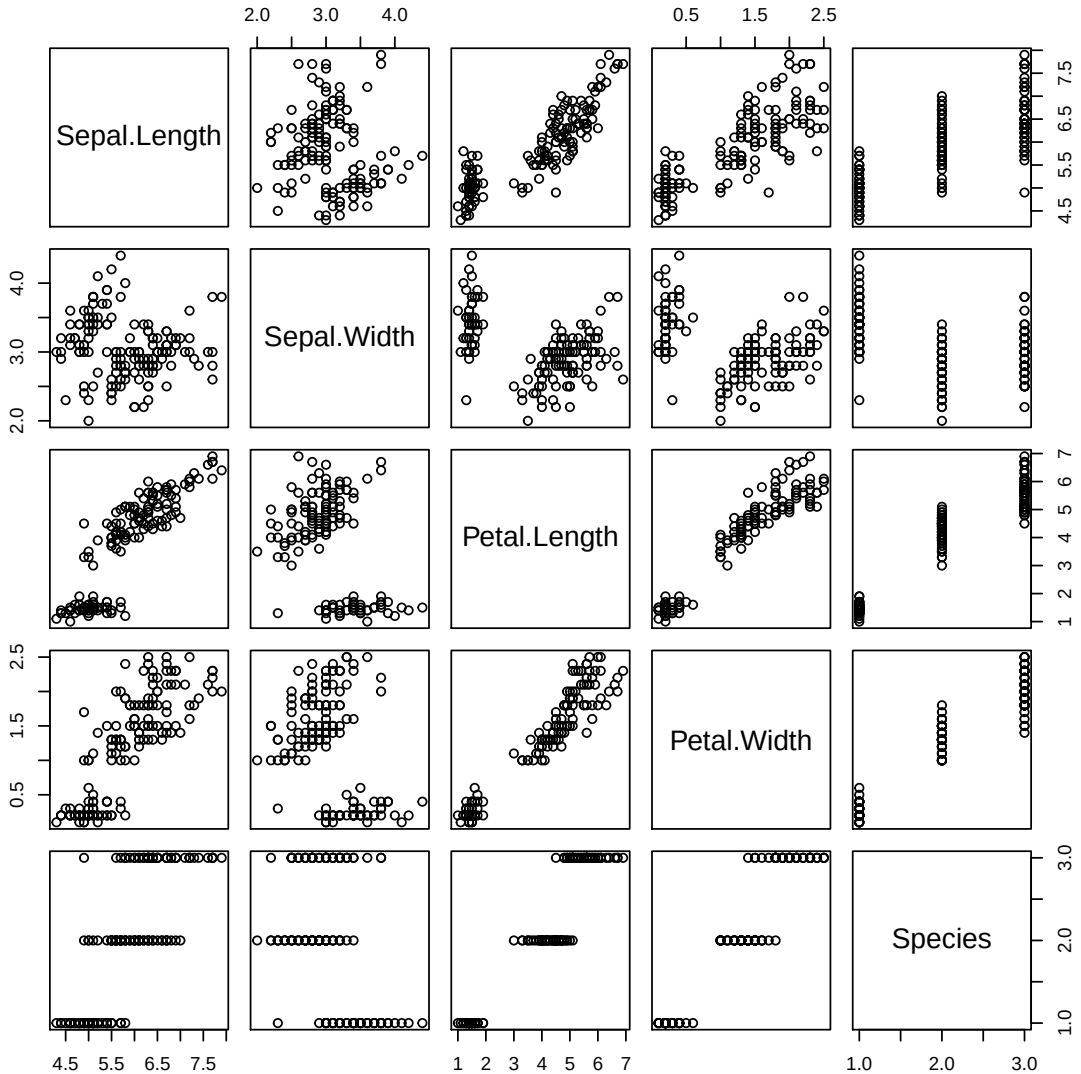
Function `jitter()`: add a small amount of noise to the data

```
with(iris, plot(jitter(Sepal.Length), jitter(Sepal.Width),
                col=Species,pch=as.numeric(Species)))
```



A Matrix of Scatter Plots

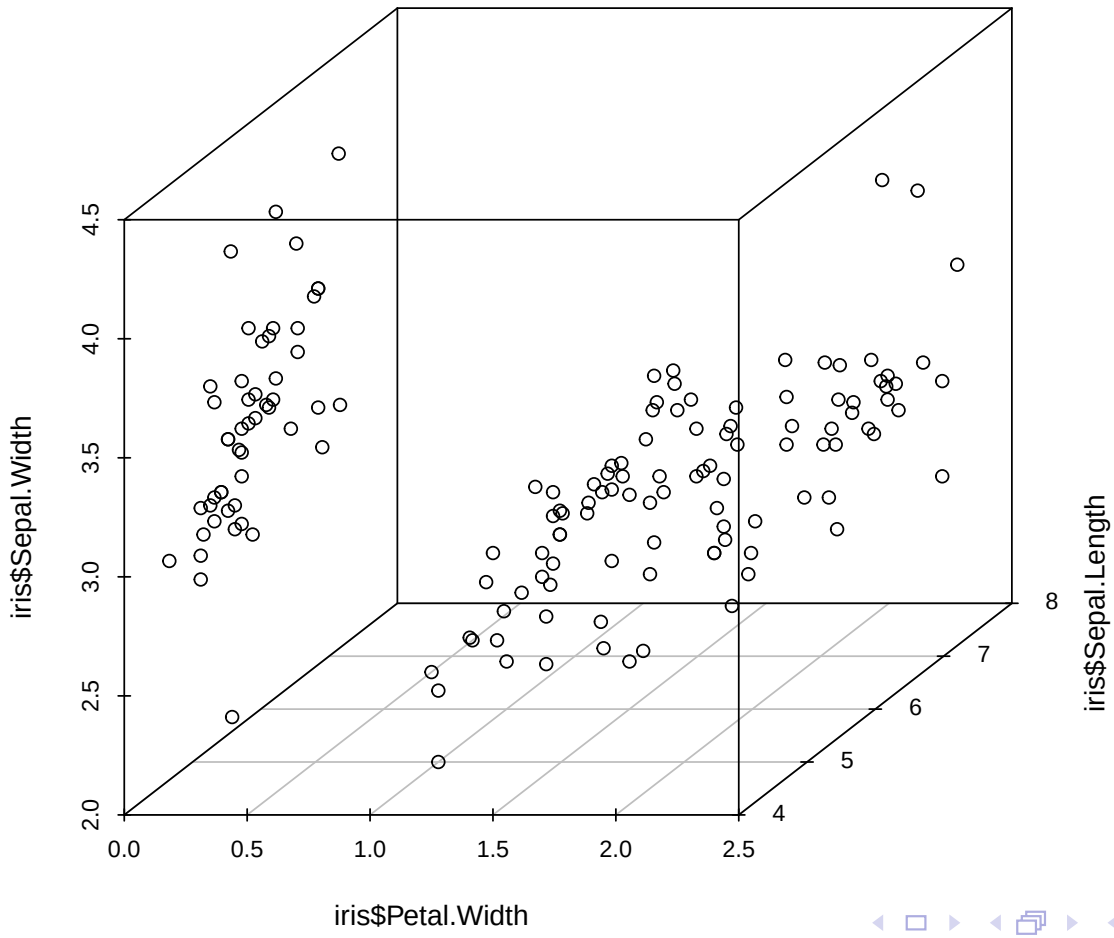
```
pairs(iris)
```



Contents

3D Scatter plot

```
library(scatterplot3d)
scatterplot3d(iris$Petal.Width, iris$Sepal.Length, iris$Sepal.Width)
```



Interactive 3D Scatter Plot

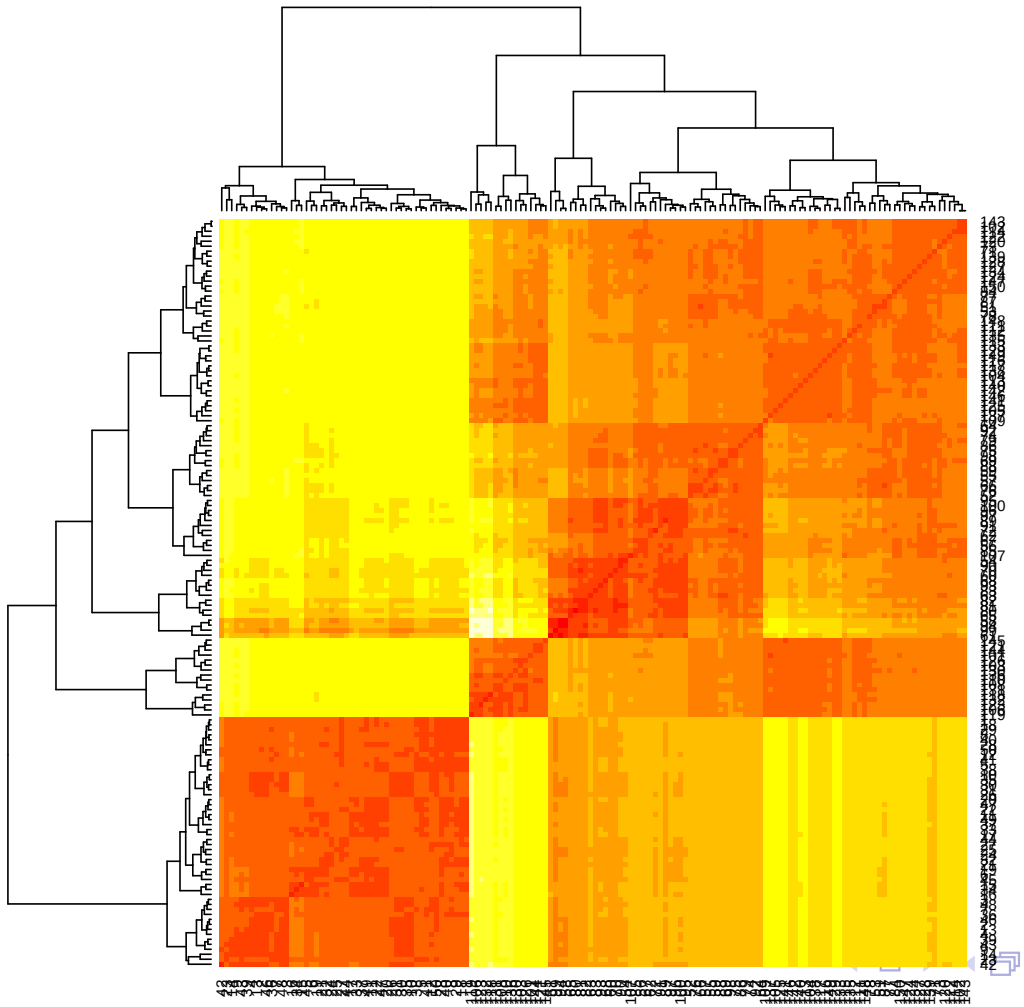
Package *rgl* supports interactive 3D scatter plot with `plot3d()`.

```
library(rgl)
plot3d(iris$Petal.Width, iris$Sepal.Length, iris$Sepal.Width)
```

Heat Map

Calculate the similarity between different flowers in the `iris` data with `dist()` and then plot it with a heat map

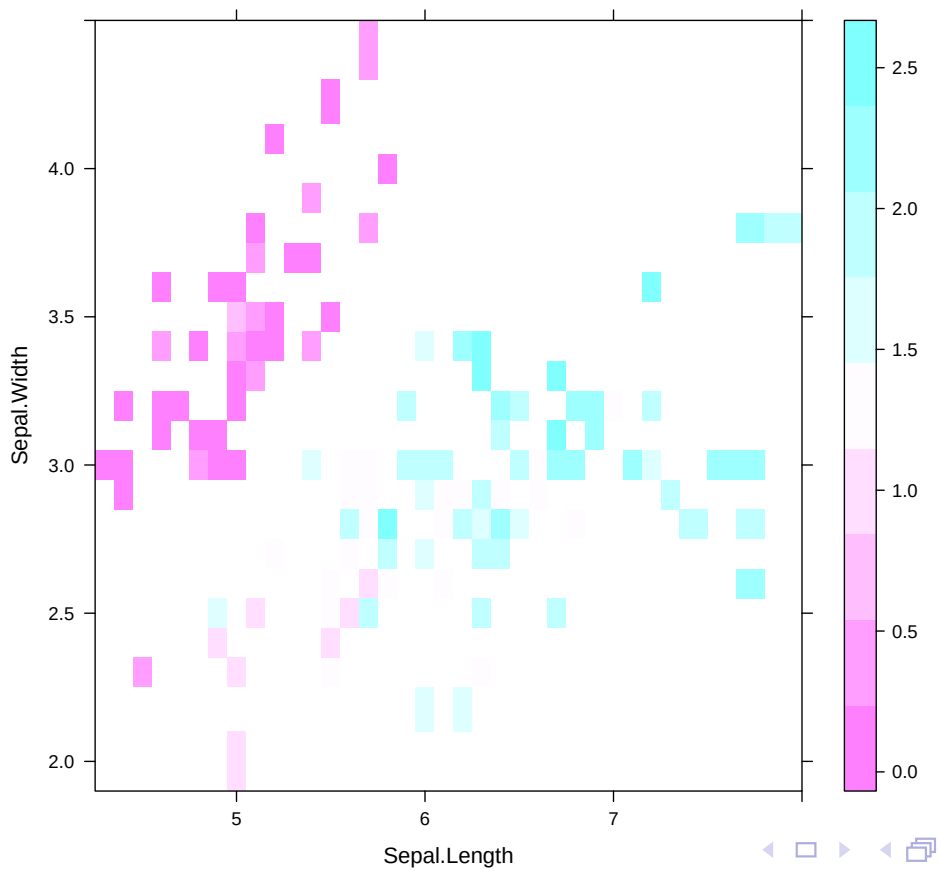
```
dist.matrix <- as.matrix(dist(iris[, 1:4]))
heatmap(dist.matrix)
```



Level Plot

Function `rainbow()` creates a vector of contiguous colors.
`rev()` reverses a vector.

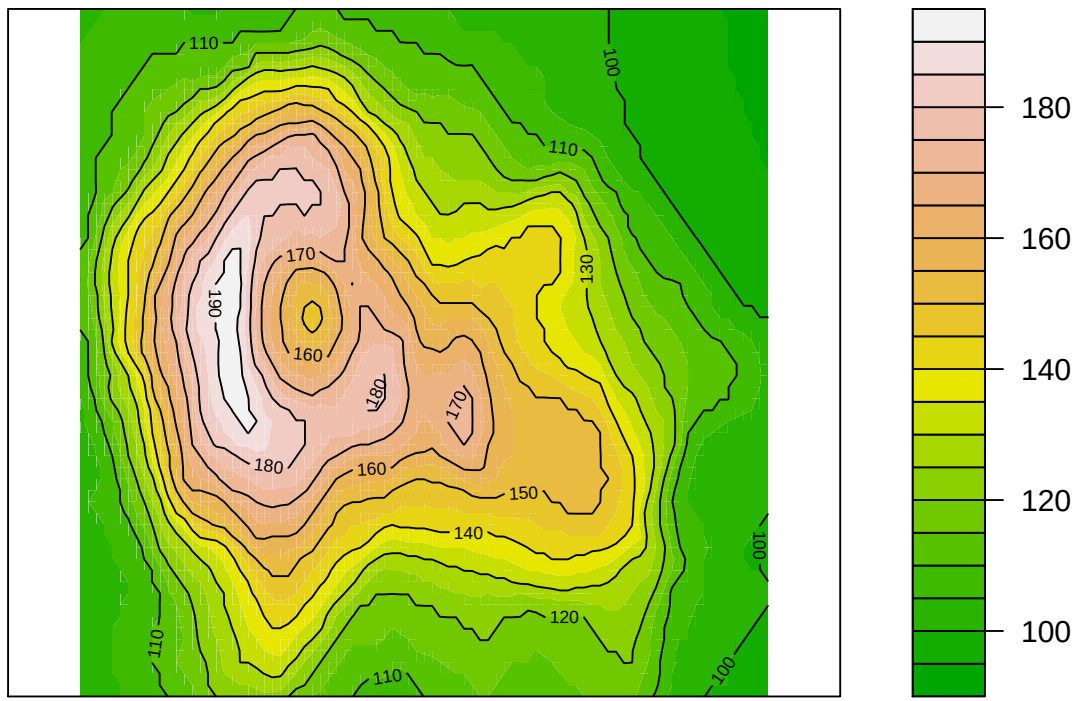
```
library(lattice)
levelplot(Petal.Width ~ Sepal.Length * Sepal.Width,
          data=iris, cuts=8)
```



Contour

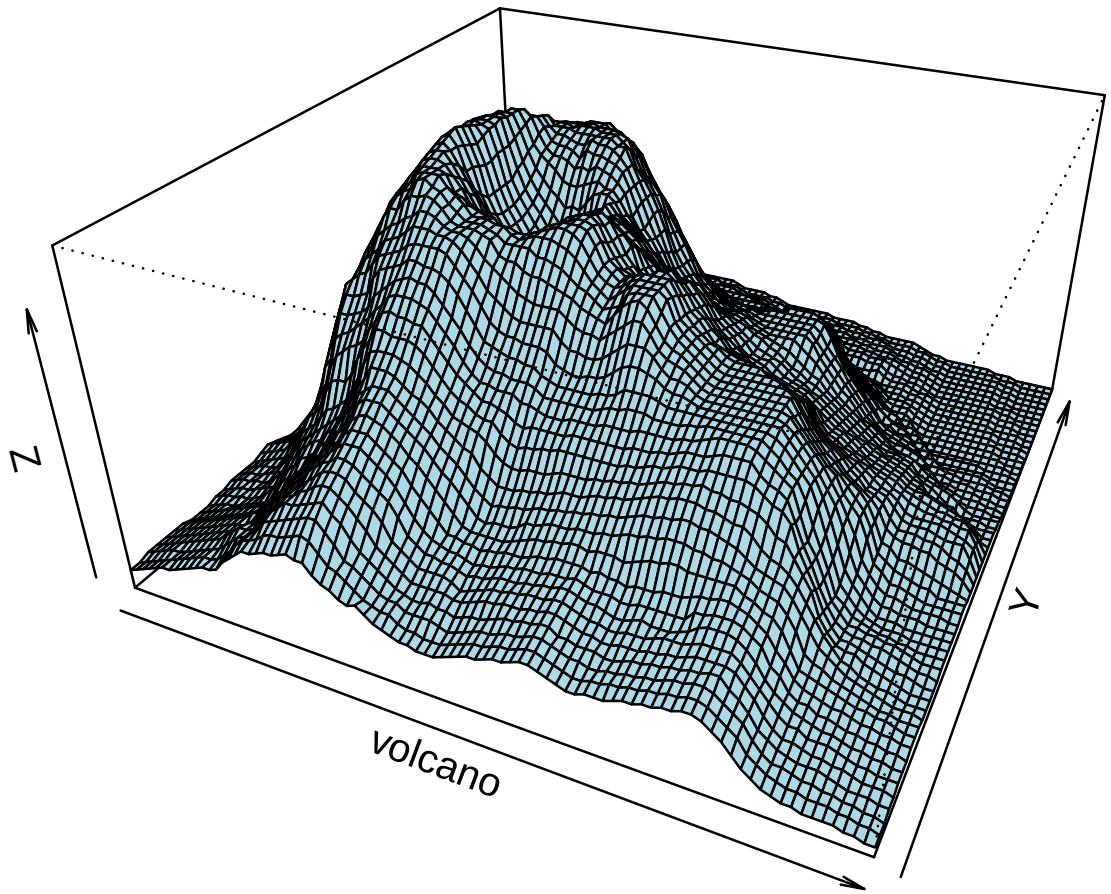
`contour()` and `filled.contour()` in package *graphics*
`contourplot()` in package *lattice*

```
filled.contour(volcano, color=terrain.colors, asp=1,
               plot.axes=contour(volcano, add=T))
```



3D Surface

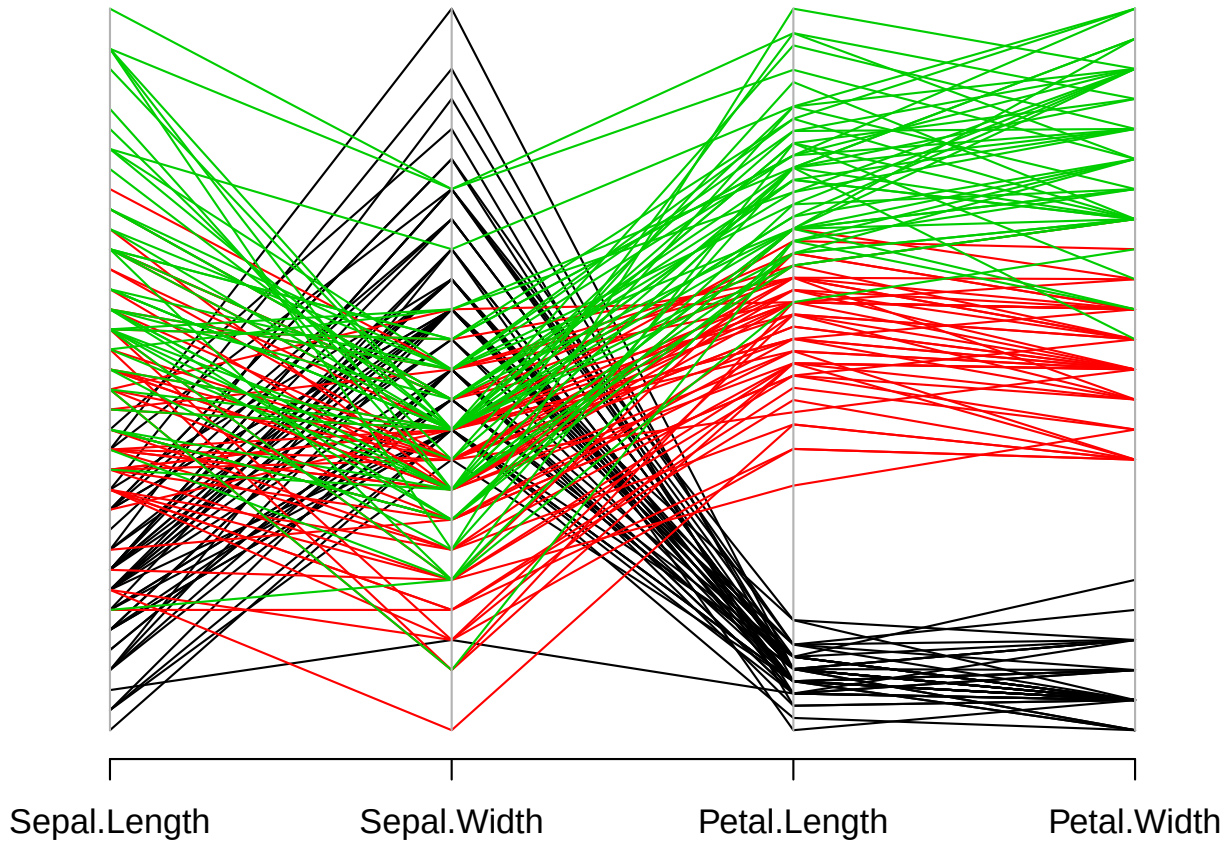
```
persp(volcano, theta = 25, phi = 30, expand = 0.5, col = "lightblue")
```



Parallel Coordinates

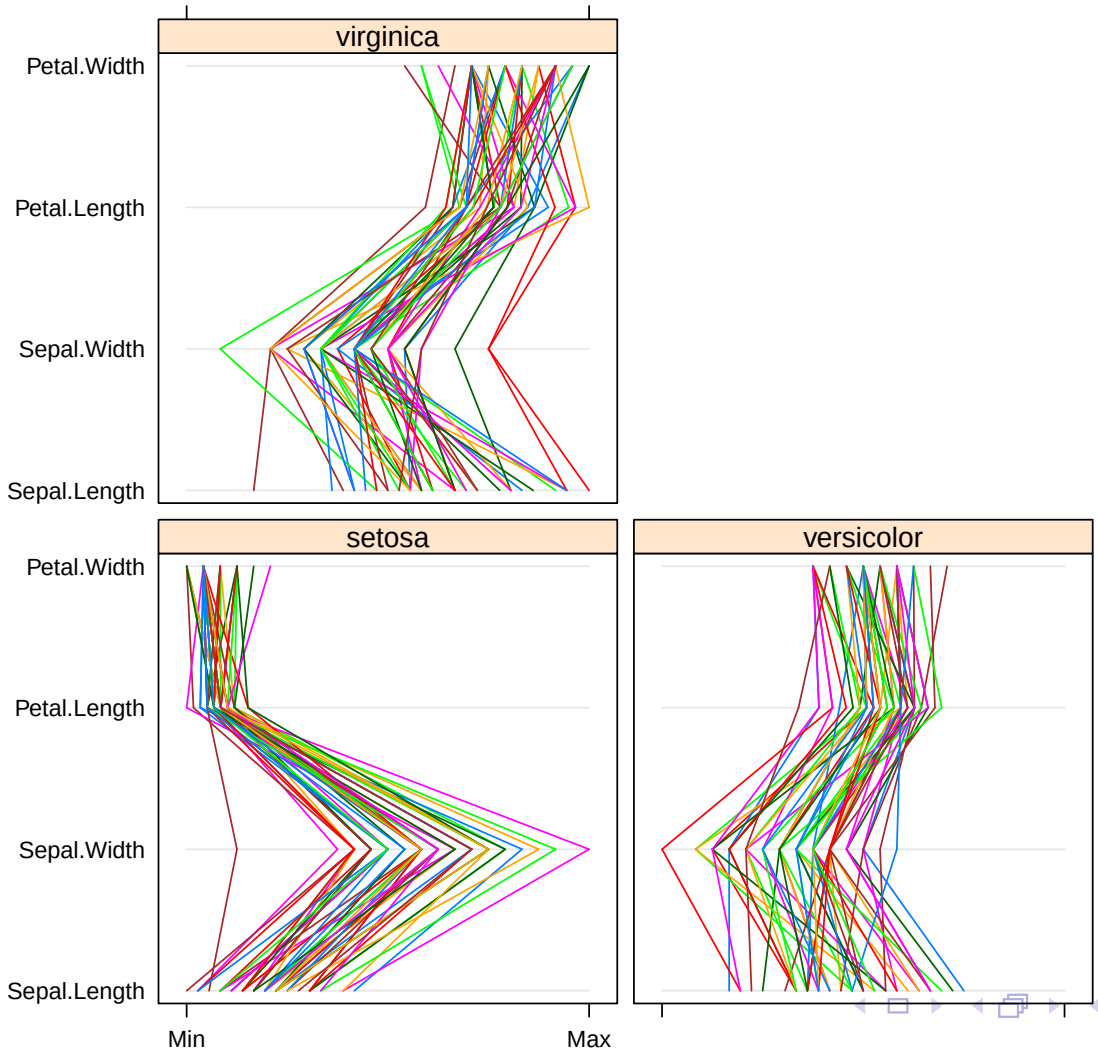
Visualising multiple dimensions

```
library(MASS)
parcoord(iris[1:4], col = iris$Species)
```



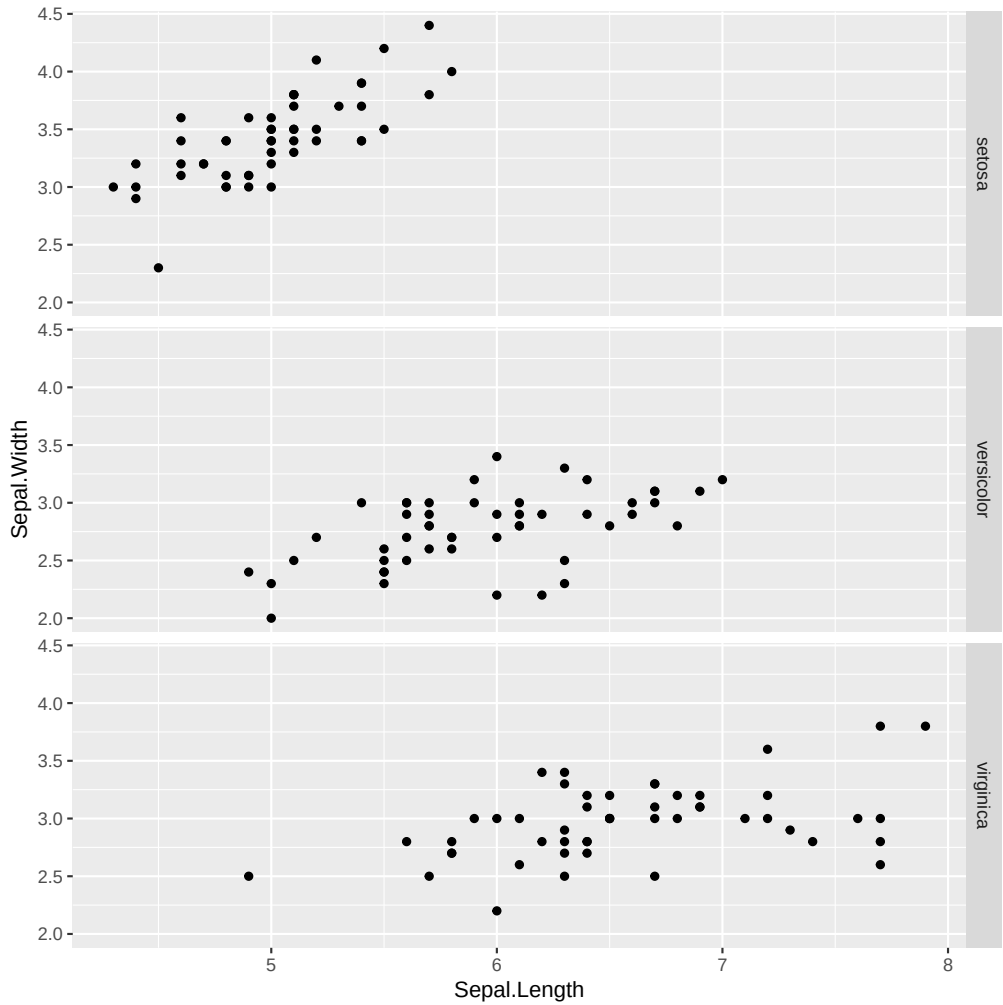
Parallel Coordinates with Package *lattice*

```
library(lattice)
parallelplot(~iris[1:4] | Species, data = iris)
```



Visualisation with Package *ggplot2*

```
library(ggplot2)
qplot(Sepal.Length, Sepal.Width, data = iris, facets = Species ~ .)
```



Contents

Save Charts to Files

- Save charts to PDF and PS files: `pdf()` and `postscript()`
- BMP, JPEG, PNG and TIFF files: `bmp()`, `jpeg()`, `png()` and `tiff()`
- Close files (or graphics devices) with `graphics.off()` or `dev.off()` after plotting

```
# save as a PDF file
pdf("myPlot.pdf")
x <- 1:50
plot(x, log(x))
graphics.off()
# Save as a postscript file
postscript("myPlot2.ps")
x <- -20:20
plot(x, x^2)
graphics.off()
```

Save ggplot Charts to Files

`ggsave()`: by defult, saving the last plot that you displayed. It also guesses the type of graphics device from the extension.

```
ggsave("myPlot3.png")
ggsave("myPlot4.pdf")
ggsave("myPlot5.jpg")
ggsave("myPlot6.bmp")
ggsave("myPlot7.ps")
ggsave("myPlot8.eps")
```

Contents

Further Readings

- Examples of ggplot2 plotting:
  `https://ggplot2.tidyverse.org/`
- Package *iplots*: interactive scatter plot, histogram, bar plot, and parallel coordinates plot (iplots)
  `http://rosuda.org/software/iPlots/`
- Package *googleVis*: interactive charts with the Google Visualisation API
  `http://cran.r-project.org/web/packages/googleVis/vignettes/googleVis_examples.html`
- Package *ggvis*: interactive grammar of graphics
  `http://ggvis.rstudio.com/`
- Package *rCharts*: interactive javascript visualisations from R
  `https://ramnathv.github.io/rCharts/`

Online Resources

- Book titled *R and Data Mining: Examples and Case Studies*

  `http://www.rdatamining.com/docs/RDataMining-book.pdf`
- R Reference Card for Data Mining

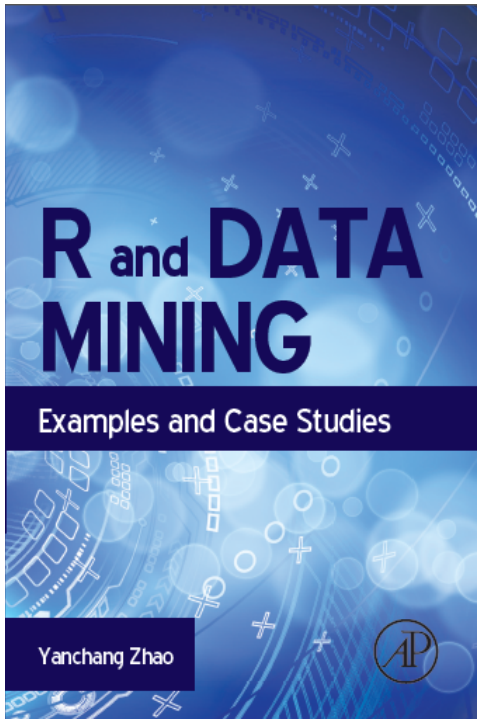
  `http://www.rdatamining.com/docs/RDataMining-reference-card.pdf`
- Free online courses and documents

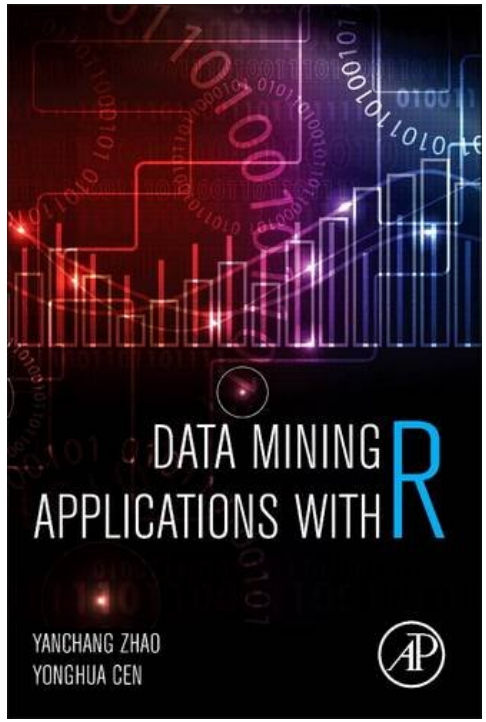
  `http://www.rdatamining.com/resources/`
- RDataMining Group on LinkedIn (27,000+ members)

  `http://group.rdatamining.com`
- Twitter (3,300+ followers)

  @RDataMining

The End





Thanks!

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How to Cite This Work

- Citation

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- BibTex

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@BOOK{Zhao2012R,
        title = {R and Data Mining: Examples and Case Studies},
        publisher = {Academic Press, Elsevier},
        year = {2012},
        author = {Yanchang Zhao},
        pages = {256},
        month = {December},
        isbn = {978-0-123-96963-7},
        keywords = {R, data mining},
        url = {http://www.rdatamining.com/docs/RDataMining-book.pdf}
}
```

References I

Frank, A. and Asuncion, A. (2010).

UCI machine learning repository. university of california, irvine, school of information and computer sciences. http://archive.ics.uci.edu/ml.