

Data Exploration and Visualization with R¹

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Outline

Introduction

Have a Look at Data

Explore Individual Variables

Explore Multiple Variables

More Explorations

Save Charts to Files

Further Readings and Online Resources

Data Exploration and Visualization with R ²

Data Exploration and Visualization

- ▶ 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 of various formats

²Chapter 3: Data Exploration, in book *R and Data Mining: Examples and Case Studies*. <http://www.rdatamining.com/docs/RDataMining.pdf>

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Size and Structure of Data

```
dim(iris)

## [1] 150    5

names(iris)

## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Wid..."
## [5] "Species"

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",....
```

Attributes of Data

```
attributes(iris)

## $names
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Wid...
## [5] "Species"
##
## $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...
##
## $class
## [1] "data.frame"
```

First 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
```


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Summary of Data

Function summary()

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

```
summary(iris)
```

```
##      Sepal.Length    Sepal.Width    Petal.Length    Petal.Width
##  Min.      :4.30    Min.      :2.00    Min.      :1.00    Min.      :0.1
## 1st Qu.:5.10    1st Qu.:2.80    1st Qu.:1.60    1st Qu.:0.3
## Median :5.80    Median :3.00    Median :4.35    Median :1.3
## Mean   :5.84    Mean   :3.06    Mean   :3.76    Mean   :1.2
## 3rd Qu.:6.40    3rd Qu.:3.30    3rd Qu.:5.10    3rd Qu.:1.8
## Max.   :7.90    Max.   :4.40    Max.   :6.90    Max.   :2.5
##
##      Species
## setosa      :50
## versicolor:50
## virginica  :50
##
##
##
```

```

library(Hmisc)
describe(iris[, c(1, 5)]) # check columns 1 & 5

## iris[, c(1, 5)]
##
## 2 Variables      150 Observations
## -----...
## Sepal.Length
##      n missing  unique      Info      Mean      .05      .10      ...
##      150        0      35        1    5.843    4.600    4.800    5...
##      .50      .75      .90      .95
##    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  unique
##      150        0        3
##
## setosa (50, 33%), versicolor (50, 33%)
## virginica (50, 33%)
## -----...

```

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%
```

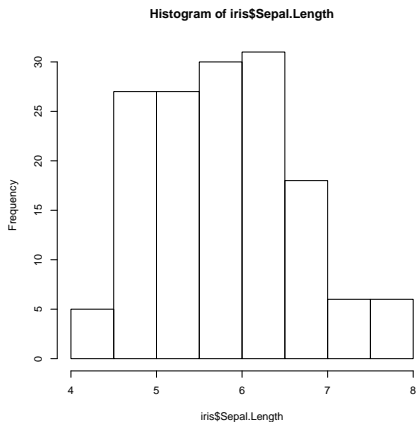
```
## 4.80 5.27 6.20
```

Variance and Histogram

```
var(iris$Sepal.Length)
```

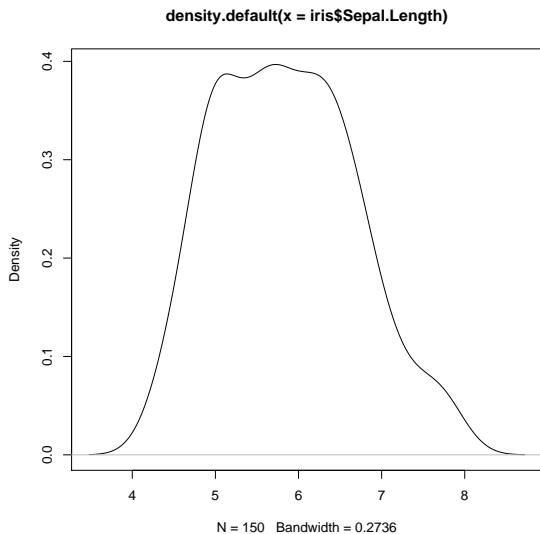
```
## [1] 0.6857
```

```
hist(iris$Sepal.Length)
```



Density

```
plot(density(iris$Sepal.Length))
```



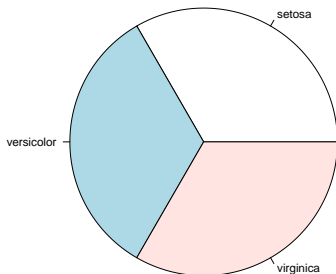
Pie Chart

Frequency of factors: `table()`

```
table(iris$Species)

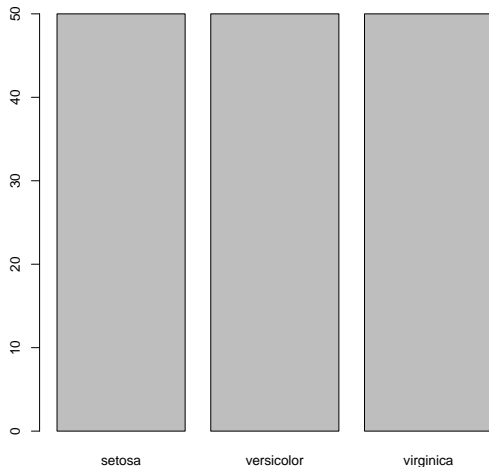
##
##      setosa versicolor  virginica
##          50          50          50

pie(table(iris$Species))
```



Bar Chart

```
barplot(table(iris$Species))
```



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Correlation

Covariance and correlation: `cov()` and `cor()`

```
cov(iris$Sepal.Length, iris$Petal.Length)
```

```
## [1] 1.274
```

```
cor(iris$Sepal.Length, iris$Petal.Length)
```

```
## [1] 0.8718
```

```
cov(iris[, 1:4])
```

```
##           Sepal.Length Sepal.Width Petal.Length Petal.Width
## Sepal.Length      0.68569   -0.04243      1.2743      0.5163
## Sepal.Width       -0.04243    0.18998     -0.3297     -0.1216
## Petal.Length      1.27432   -0.32966      3.1163      1.2956
## Petal.Width       0.51627   -0.12164      1.2956      0.5810
```

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

Aggreation

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

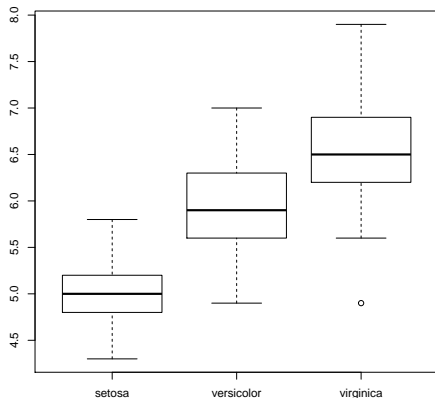
```
aggregate(Sepal.Length ~ Species, summary, data = iris)
```

```
##      Species Sepal.Length.Min. Sepal.Length.1st Qu.  
## 1      setosa              4.30              4.80  
## 2 versicolor              4.90              5.60  
## 3  virginica              4.90              6.22  
##      Sepal.Length.Median Sepal.Length.Mean Sepal.Length.3rd Qu.  
## 1              5.00              5.01              5.20  
## 2              5.90              5.94              6.30  
## 3              6.50              6.59              6.90  
##      Sepal.Length.Max.  
## 1              5.80  
## 2              7.00  
## 3              7.90
```

Boxplot

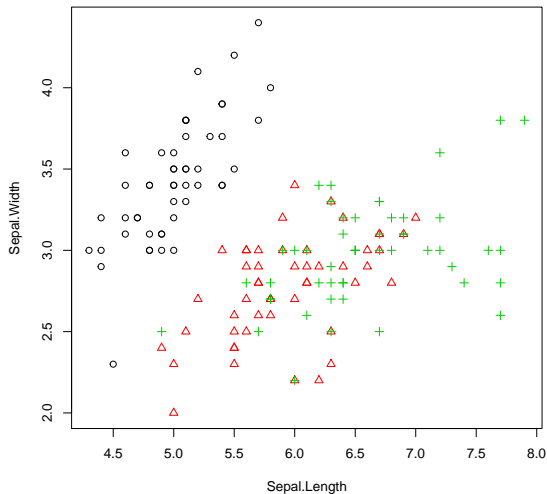
- ▶ The bar in the middle is median.
- ▶ The box shows the interquartile range (IQR), i.e., range between the 75% and 25% observation.

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



Scatter Plot

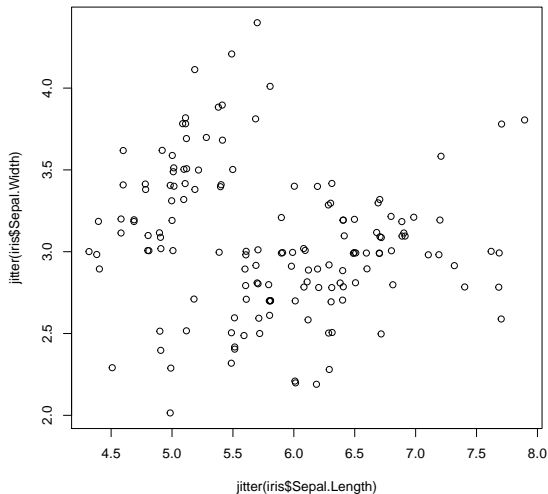
```
with(iris, plot(Sepal.Length, Sepal.Width, col = Species,  
               pch = as.numeric(Species)))
```



Scatter Plot with Jitter

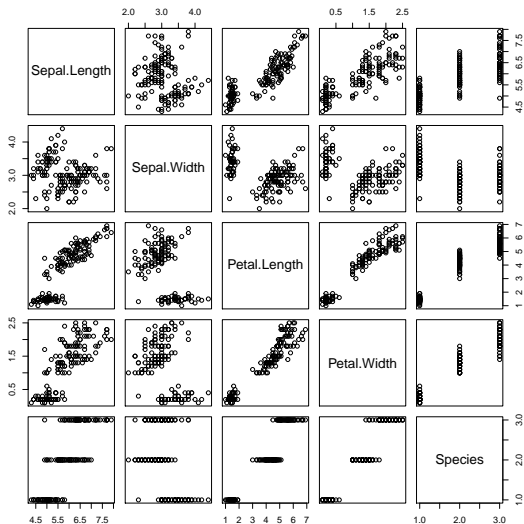
Function `jitter()`: add a small amount of noise to the data

```
plot(jitter(iris$Sepal.Length), jitter(iris$Sepal.Width))
```



A Matrix of Scatter Plots

```
pairs(iris)
```



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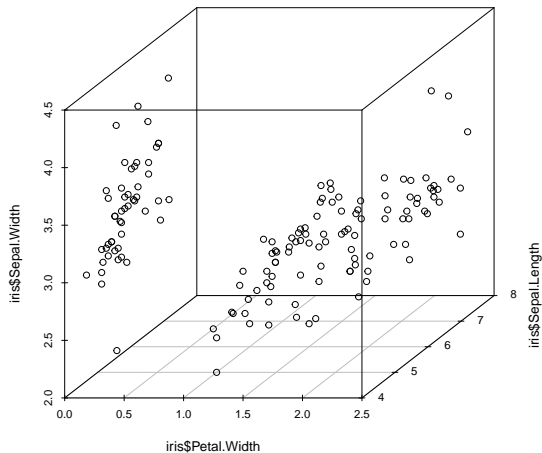
More Explorations

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Further Readings and Online Resources

3D Scatter plot

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



Interactive 3D Scatter Plot

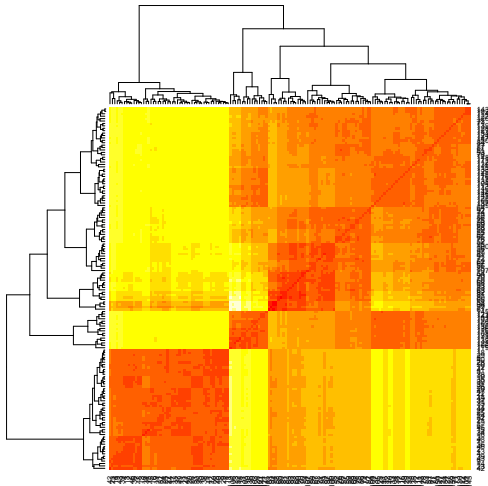
Package *rgl* supports interactive 3D scatter plot with `plot3d()`.

```
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

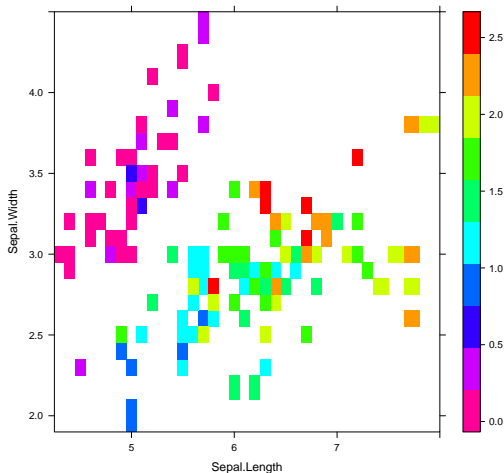
```
dist.matrix <- as.matrix(dist(iris[, 1:4]))  
heatmap(dist.matrix)
```



Level Plot

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

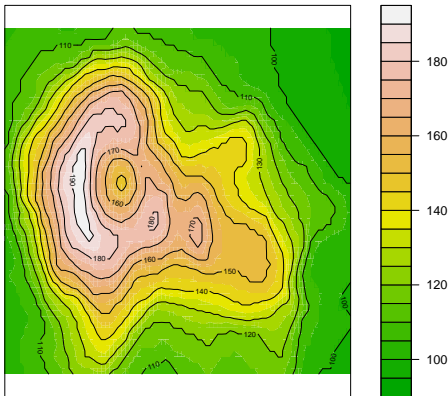
```
library(lattice)
levelplot(Petal.Width ~ Sepal.Length * Sepal.Width, iris, cuts = 9,
          col.regions = rainbow(10)[10:1])
```



Contour

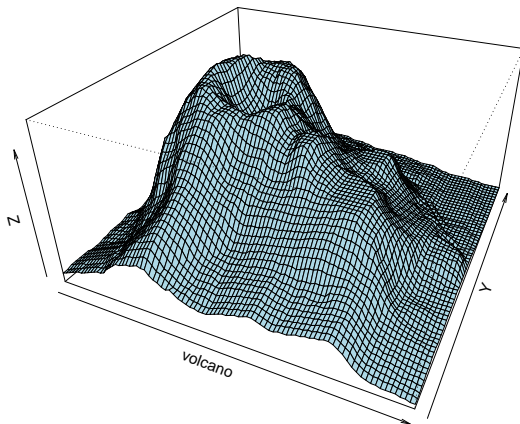
`contour()` and `filled.contour()` in package *graphics*
`contourplot()` in package *lattice*

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



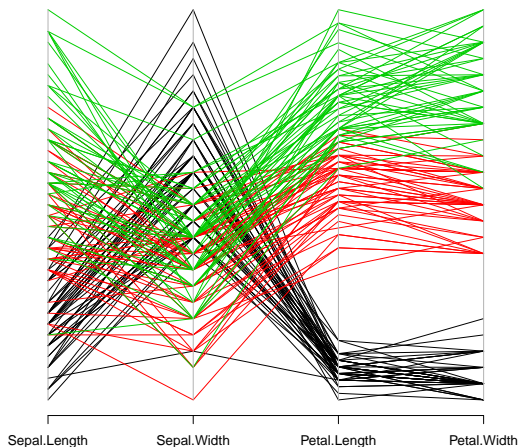
3D Surface

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



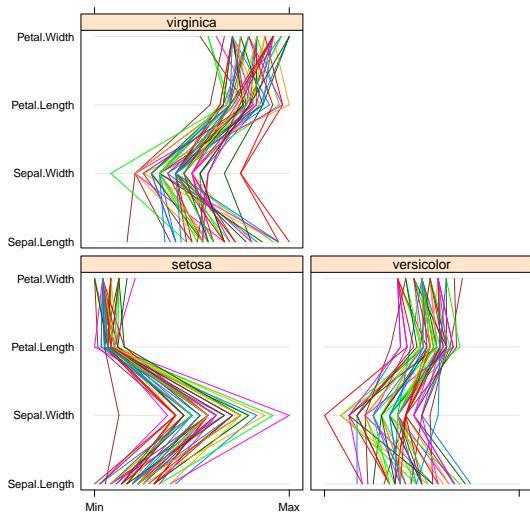
Parallel Coordinates

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



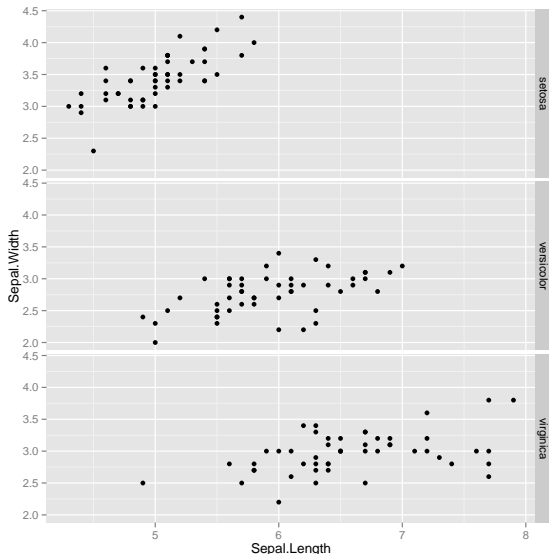
Parallel Coordinates with Package *lattice*

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



Visualization with Package *ggplot2*

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



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- ▶ 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()
```

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Further Readings

- ▶ Examples of ggplot2 plotting:
<http://had.co.nz/ggplot2/>
- ▶ Package *iplots*: interactive scatter plot, histogram, bar plot, and parallel coordinates plot (iplots)
<http://stats.math.uni-augsburg.de/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 visualizations from R
<http://rcharts.io/>

Online Resources

- ▶ Chapter 3: Data Exploration, in book *R and Data Mining: Examples and Case Studies*

<http://www.rdatamining.com/docs/RDataMining.pdf>

- ▶ R Reference Card for Data Mining

<http://www.rdatamining.com/docs/R-refcard-data-mining.pdf>

- ▶ Free online courses and documents

<http://www.rdatamining.com/resources/>

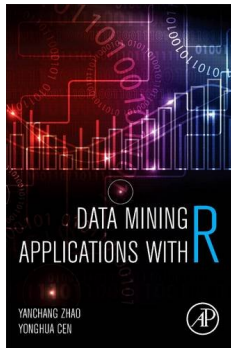
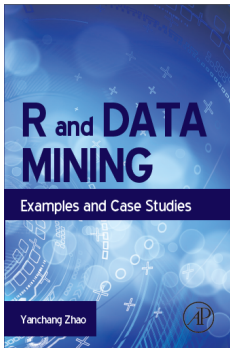
- ▶ RDataMining Group on LinkedIn (8,000+ members)

<http://group.rdatamining.com>

- ▶ RDataMining on Twitter (1,800+ followers)

@RDataMining

The End



Thanks!

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