An Introduction to Data Mining with R

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Questions

- Do you know data mining and techniques for it?

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- Have you used R before?

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- Do you know data mining and techniques for it?
- Have you used R before?
- Have you used R in your data mining research or projects?

Outline

Introduction

Classification with R

Clustering with R

Association Rule Mining with R

Text Mining with R

Time Series Analysis with R

Social Network Analysis with R

R and Hadoop

Online Resources

What is R?

- R [1] is a free software environment for statistical computing and graphics.
- R can be easily extended with 4,728 packages available on CRAN[2] (as of Sept 6, 2013).
- Many other packages provided on Bioconductor[3], R-Forge[4], GitHub[5], etc.
- R manuals on CRAN[6]
  - *An Introduction to R*
  - *The R Language Definition*
  - *R Data Import/Export*
  - ...

[1] http://www.r-project.org/

[2] http://cran.r-project.org/

[3] http://www.bioconductor.org/

[4] http://r-forge.r-project.org/

[5] https://github.com/

[6] http://cran.r-project.org/manuals.html

Why R?

- R is widely used in both academia and **industry**.
- R is ranked no. 1 again in the KDnuggets 2013 poll on *Top Languages for analytics, data mining, data science*[7].
- The CRAN Task Views [8] provide collections of packages for different tasks.
  - Machine learning & atatistical learning
  - Cluster analysis & finite mixture models
  - Time series analysis
  - Multivariate statistics
  - Analysis of spatial data
  - ...

[7] http://www.kdnuggets.com/2013/08/languages-for-analytics-data-mining-data-science.html

[8] http://cran.r-project.org/web/views/

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Classification with R

- Decision trees: *rpart*, *party*
- Random forest: *randomForest*, *party*
- SVM: *e1071*, *kernlab*
- Neural networks: *nnet*, *neuralnet*, *RSNNS*
- Performance evaluation: *ROCR*

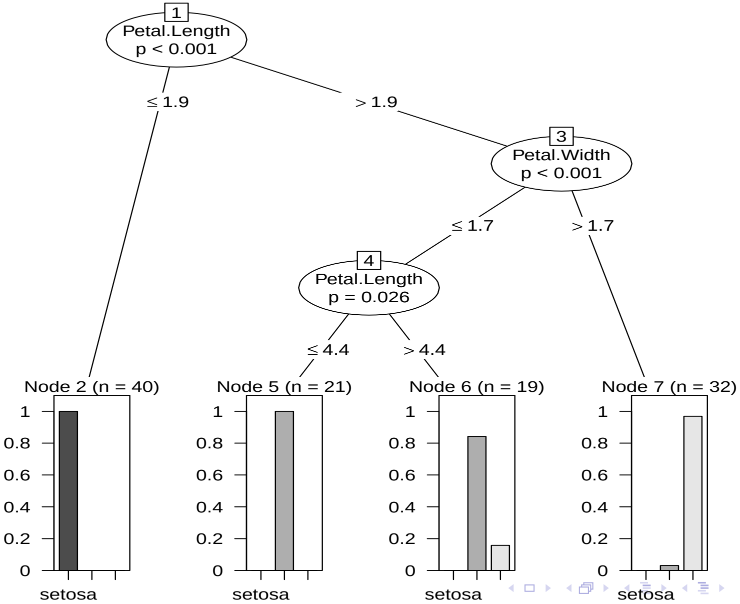
The Iris Dataset

```
# iris data
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 1.5
##  $ Petal.Width : num  0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1
##  $ Species     : Factor w/ 3 levels "setosa","versicolor",..:

# split into training and test datasets
set.seed(1234)
ind <- sample(2, nrow(iris), replace=T, prob=c(0.7, 0.3))
iris.train <- iris[ind==1, ]
iris.test <- iris[ind==2, ]
```

Build a Decision Tree

```
# build a decision tree
library(party)
iris.formula <- Species ~ Sepal.Length + Sepal.Width +
                          Petal.Length + Petal.Width
iris.ctree <- ctree(iris.formula, data=iris.train)
```

```
plot(iris.ctree)
```



Prediction

```
# predict on test data
pred <- predict(iris.ctree, newdata = iris.test)
# check prediction result
table(pred, iris.test$Species)

##
## pred         setosa versicolor virginica
##   setosa         10          0         0
##   versicolor      0         12         2
##   virginica       0          0        14
```

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Clustering with R

- *k*-means: *kmeans()*, *kmeansruns()*[9]
- *k*-medoids: *pam()*, *pamk()*
- Hierarchical clustering: *hclust()*, *agnes()*, *diana()*
- DBSCAN: *fpc*
- BIRCH: *birch*

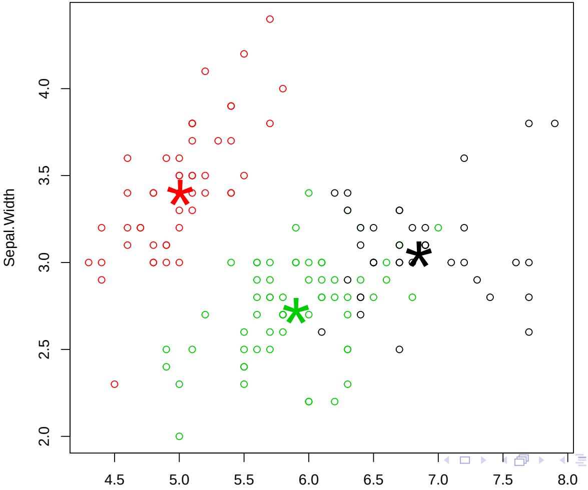
[9] Functions are followed with "()", and others are packages.

k-means Clustering

```
set.seed(8953)
iris2 <- iris
# remove class IDs
iris2$Species <- NULL
# k-means clustering
iris.kmeans <- kmeans(iris2, 3)
# check result
table(iris$Species, iris.kmeans$cluster)

##
##                1  2  3
##   setosa       0 50  0
##   versicolor   2  0 48
##   virginica   36  0 14
```

```
# plot clusters and their centers
plot(iris2[c("Sepal.Length", "Sepal.Width")], col=iris.kmeans$cluster)
points(iris.kmeans$centers[, c("Sepal.Length", "Sepal.Width")],
       col=1:3, pch="*", cex=5)
```

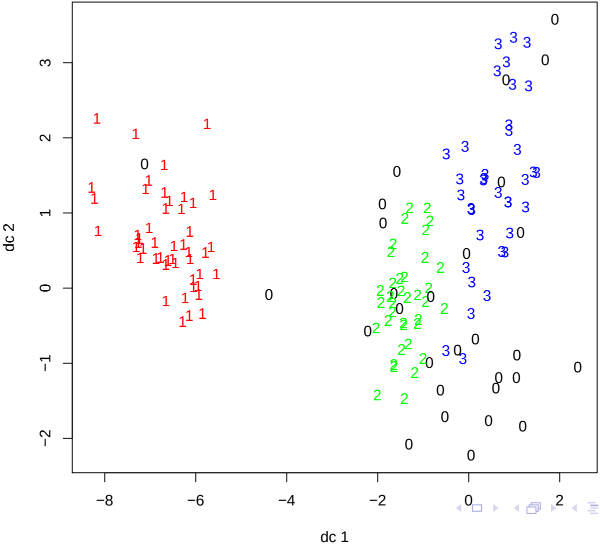


Density-based Clustering

```
library(fpc)
iris2 <- iris[-5]  # remove class IDs
# DBSCAN clustering
ds <- dbscan(iris2, eps = 0.42, MinPts = 5)
# compare clusters with original class IDs
table(ds$cluster, iris$Species)

##
##     setosa versicolor virginica
##   0      2         10        17
##   1     48          0         0
##   2      0         37         0
##   3      0          3        33
```

```
# 1-3: clusters; 0: outliers or noise
plotcluster(iris2, ds$cluster)
```



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Association Rule Mining with R

- Association rules: *apriori()*, *eclat()* in package *arules*
- Sequential patterns: *arulesSequence*
- Visualisation of associations: *arulesViz*

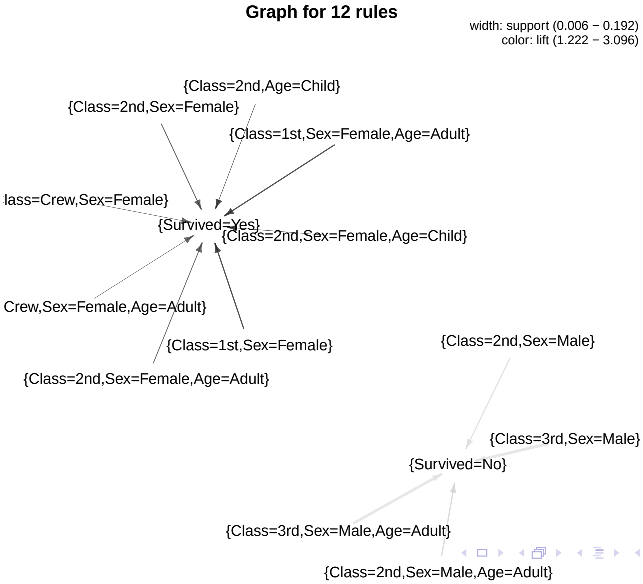
The Titanic Dataset

```
load("./data/titanic.raw.rdata")
dim(titanic.raw)

## [1] 2201    4

idx <- sample(1:nrow(titanic.raw), 8)
titanic.raw[idx, ]

##       Class    Sex   Age Survived
## 501    3rd   Male Adult       No
## 477    3rd   Male Adult       No
## 674    3rd   Male Adult       No
## 766   Crew   Male Adult       No
## 1485   3rd Female Adult       No
## 1388   2nd Female Adult       No
## 448    3rd   Male Adult       No
## 590    3rd   Male Adult       No
```

Association Rule Mining

```r
# find association rules with the APRIORI algorithm
library(arules)
rules <- apriori(titanic.raw, control=list(verbose=F),
                 parameter=list(minlen=2, supp=0.005, conf=0.8),
                 appearance=list(rhs=c("Survived=No", "Survived=Yes"),
                                 default="lhs"))
# sort rules
quality(rules) <- round(quality(rules), digits=3)
rules.sorted <- sort(rules, by="lift")
# have a look at rules
# inspect(rules.sorted)
#    lhs               rhs              support confidence  lift
# 1  {Class=2nd,
#     Age=Child}    => {Survived=Yes}   0.011      1.000 3.096
# 2  {Class=2nd,
#     Sex=Female,
#     Age=Child}    => {Survived=Yes}   0.006      1.000 3.096
# 3  {Class=1st,
#     Sex=Female}   => {Survived=Yes}   0.064      0.972 3.010
# 4  {Class=1st,
#     Sex=Female,
#     Age=Adult}    => {Survived=Yes}   0.064      0.972 3.010
# 5  {Class=2nd,
#     Sex=Male,
#     Age=Adult}    => {Survived=No}    0.070      0.917 1.354
# 6  {Class=2nd,
#     Sex=Female}   => {Survived=Yes}   0.042      0.877 2.716
# 7  {Class=Crew,
#     Sex=Female}   => {Survived=Yes}   0.009      0.870 2.692
# 8  {Class=Crew,
#     Sex=Female,
#     Age=Adult}    => {Survived=Yes}   0.009      0.870 2.692
# 9  {Class=2nd,
#     Sex=Male}     => {Survived=No}    0.070      0.860 1.271
# 10 {Class=2nd,
```

```r
library(arulesViz)
plot(rules, method = "graph")
```


Graph for 12 rules
width: support (0.006 − 0.192)
color: lift (1.222 − 3.096)
{Class=2nd,Age=Child}
{Class=2nd,Sex=Female}
{Class=1st,Sex=Female,Age=Adult}
lass=Crew,Sex=Female}
{Survived=Yes}
{Class=2nd,Sex=Female,Age=Child}
Crew,Sex=Female,Age=Adult}
{Class=1st,Sex=Female}
{Class=2nd,Sex=Female,Age=Adult}
{Class=2nd,Sex=Male}
{Class=3rd,Sex=Male}
{Survived=No}
{Class=3rd,Sex=Male,Age=Adult}
{Class=2nd,Sex=Male,Age=Adult}

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Text Mining with R

- Text mining: *tm*
- Topic modelling: *topicmodels*, *lda*
- Word cloud: *wordcloud*
- Twitter data access: *twitteR*

Fetch Twitter Data

```
## retrieve tweets from the user timeline of @rdatammining
library(twitteR)
# tweets <- userTimeline('rdatamining')
load(file = "./data/rdmTweets.RData")
(nDocs <- length(tweets))

## [1] 320

strwrap(tweets[[320]]$text, width = 50)

## [1] "An R Reference Card for Data Mining is now"
## [2] "available on CRAN. It lists many useful R"
## [3] "functions and packages for data mining"
## [4] "applications."

# convert tweets to a data frame
df <- do.call("rbind", lapply(tweets, as.data.frame))
```

Text Cleaning

```
library(tm)
# build a corpus
myCorpus <- Corpus(VectorSource(df$text))
# convert to lower case
myCorpus <- tm_map(myCorpus, tolower)
# remove punctuation & numbers
myCorpus <- tm_map(myCorpus, removePunctuation)
myCorpus <- tm_map(myCorpus, removeNumbers)
# remove URLs
removeURL <- function(x) gsub("http[[:alnum:]]*", "", x)
myCorpus <- tm_map(myCorpus, removeURL)
# remove 'r' and 'big' from stopwords
myStopwords <- setdiff(stopwords("english"), c("r", "big"))
# remove stopwords
myCorpus <- tm_map(myCorpus, removeWords, myStopwords)
```

Stemming

```
# keep a copy of corpus
myCorpusCopy <- myCorpus
# stem words
myCorpus <- tm_map(myCorpus, stemDocument)
# stem completion
myCorpus <- tm_map(myCorpus, stemCompletion,
                   dictionary = myCorpusCopy)
# replace "miners" with "mining", because "mining" was
# first stemmed to "mine" and then completed to "miners"
myCorpus <- tm_map(myCorpus, gsub, pattern="miners",
                   replacement="mining")
strwrap(myCorpus[320], width=50)

## [1] "r reference card data mining now available cran"
## [2] "list used r functions package data mining"
## [3] "applications"
```

Frequent Terms

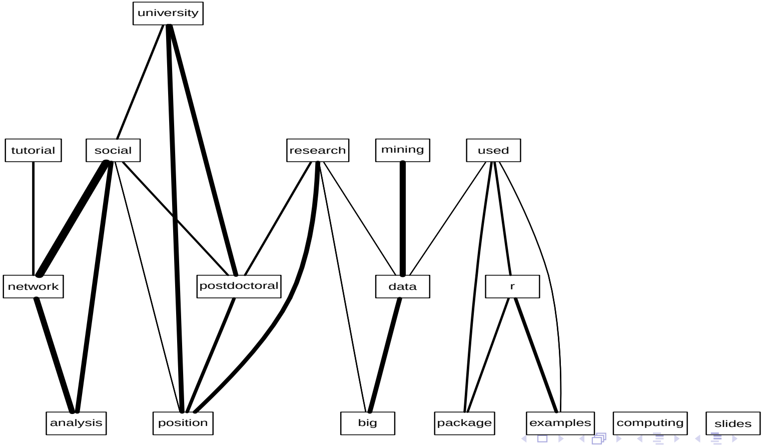
```
myTdm <- TermDocumentMatrix(myCorpus,
                            control=list(wordLengths=c(1,Inf)))
# inspect frequent words
(freq.terms <- findFreqTerms(myTdm, lowfreq=20))

##  [1] "analysis"     "big"          "computing"
##  [4] "data"         "examples"     "mining"
##  [7] "network"      "package"      "position"
## [10] "postdoctoral" "r"            "research"
## [13] "slides"       "social"       "tutorial"
## [16] "university"   "used"
```

Associations

```
# which words are associated with 'r'?
findAssocs(myTdm, "r", 0.2)

## examples     code  package
##     0.32     0.29     0.20

# which words are associated with 'mining'?
findAssocs(myTdm, "mining", 0.25)

##           data         mahout recommendation           sets
##           0.47           0.30           0.30           0.30
##       supports       frequent        itemset
##           0.30           0.26           0.26
```

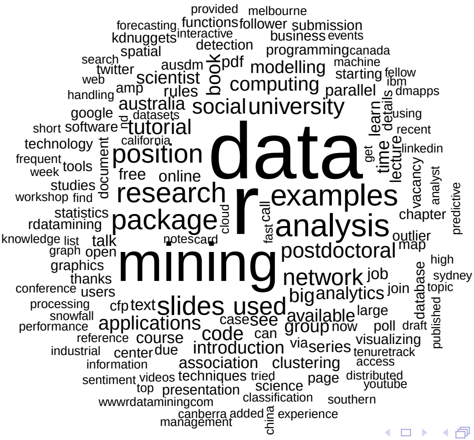
Network of Terms

```r
library(graph)
library(Rgraphviz)
plot(myTdm, term=freq.terms, corThreshold=0.1, weighting=T)
```



Word Cloud

```
library(wordcloud)
m <- as.matrix(myTdm)
freq <- sort(rowSums(m), decreasing=T)
wordcloud(words=names(freq), freq=freq, min.freq=4, random.order=F)
```



Topic Modelling

```
library(topicmodels)
set.seed(123)
myLda <- LDA(as.DocumentTermMatrix(myTdm), k=8)
terms(myLda, 5)

##      Topic 1       Topic 2    Topic 3  Topic 4
## [1,] "data"        "r"        "r"      "research"
## [2,] "mining"      "package"  "time"   "position"
## [3,] "big"         "examples" "series" "data"
## [4,] "association" "used"     "users"  "university"
## [5,] "rules"       "code"     "talk"   "postdoctoral"
##      Topic 5     Topic 6     Topic 7    Topic 8
## [1,] "mining"    "group"     "data"     "analysis"
## [2,] "data"      "data"      "r"        "network"
## [3,] "slides"    "used"      "mining"   "social"
## [4,] "modelling" "software"  "analysis" "text"
## [5,] "tools"     "kdnuggets" "book"     "slides"
```

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Time Series Analysis with R

- Time series decomposition: *decomp()*, *decompose()*, *arima()*, *stl()*
- Time series forecasting: *forecast*
- Time Series Clustering: *TSclust*
- Dynamic Time Warping (DTW): *dtw*

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Social Network Analysis with R

- Packages: *igraph*, *sna*
- Centrality measures: *degree(), betweenness(), closeness(), transitivity()*
- Clusters: *clusters(), no.clusters()*
- Cliques: *cliques(), largest.cliques(), maximal.cliques(), clique.number()*
- Community detection: *fastgreedy.community(), spinglass.community()*

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R and Hadoop

- Packages: RHadoop, RHive
- RHadoop[10] is a collection of 3 R packages:
  - *rmr2* - perform data analysis with R via MapReduce on a Hadoop cluster
  - *rhdfs* - connect to Hadoop Distributed File System (HDFS)
  - *rhbase* - connect to the NoSQL HBase database
- You can play with it on a single PC (in standalone or pseudo-distributed mode), and your code developed on that will be able to work on a cluster of PCs (in full-distributed mode)!
- Step by step to set up my first R Hadoop system `http://www.rdatamining.com/tutorials/rhadoop`

[10] `https://github.com/RevolutionAnalytics/RHadoop/wiki`

An Example of MapReducing with R

```r
library(rmr2)
map <- function(k, lines) {
    words.list <- strsplit(lines, "\\s")
    words <- unlist(words.list)
    return(keyval(words, 1))
}
reduce <- function(word, counts) {
    keyval(word, sum(counts))
}
wordcount <- function(input, output = NULL) {
    mapreduce(input = input, output = output, input.format = "text",
        map = map, reduce = reduce)
}
## Submit job
out <- wordcount(in.file.path, out.file.path)
```

[11]

[11] From Jeffrey Breen's presentation on *Using R with Hadoop*
http://www.revolutionanalytics.com/news-events/free-webinars/2013/using-r-with-hadoop/

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Online Resources

- RDataMining website

  `http://www.rdatamining.com`

  - R Reference Card for Data Mining
  - R and Data Mining: Examples and Case Studies

- RDataMining Group on LinkedIn (3100+ members)

  `http://group.rdatamining.com`

- RDataMining on Twitter (1200+ followers)

  `http://twitter.com/rdatamining`

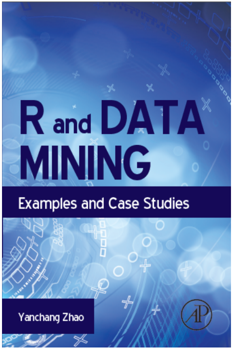
- Free online courses

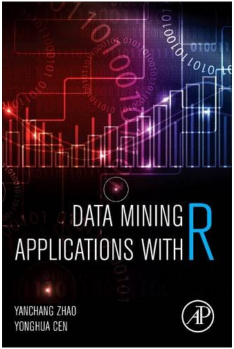
  `http://www.rdatamining.com/resources/courses`

- Online documents

  `http://www.rdatamining.com/resources/onlinedocs`

The End





Thanks!

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