Data analysis using R

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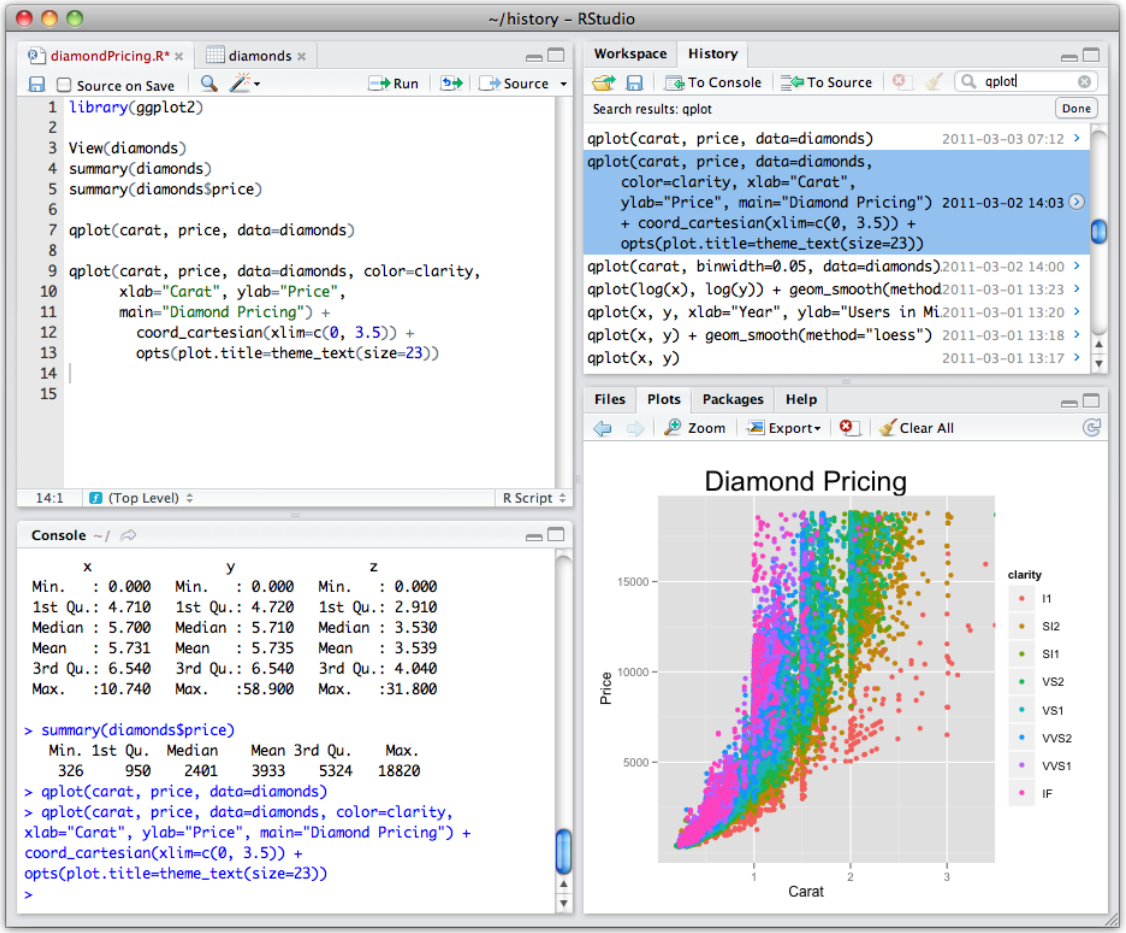
Agenda

- What is R?
- Introduction to R
- Introduction to Machine Learning and Data Ming
- Exercises

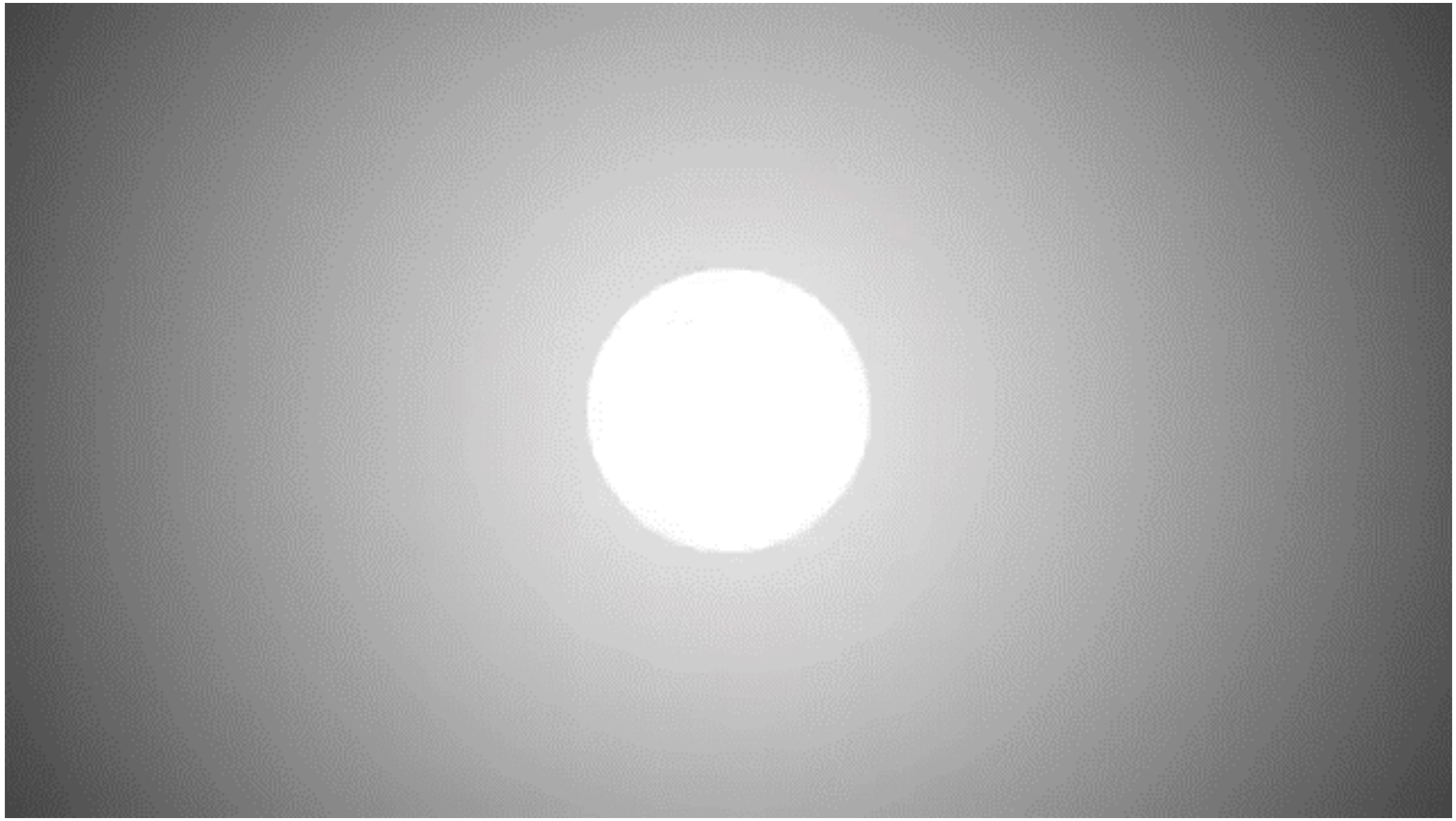
R Programing language



What is R ?

- Scripting programming language;
- Open Source;
- A tool for Data Scientists:
  - Statistical analysis;
  - Data mining;
  - Machine Learning.

What is R ?



Top 10 Programming Languages to Learn

1.	Java	100.0
2.	C	99.2
3.	C++	95.5
4.	Python	93.4
5.	C#	92.2
6.	PHP	84.6
7.	Javascript	84.3
8.	Ruby	78.6
9.	R	74.0
10.	MATLAB	

2015

Top 10 programming language IEEE spectrum

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1. Java	1. Java	100.0
2. C	2. C	99.9
3. C++	3. C++	99.6
4. Python	4. Python	95.8
5. C#	5. C#	91.8
	6. R	84.7
7. Javascrip	7. PHP	84.5
8. Ruby	8. JavaScript	83.0
9. R	9. Ruby	
10. MATLAB	10. Matlab	2.4
	11. Shell	.4
	12. SQL	

Top

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Installation

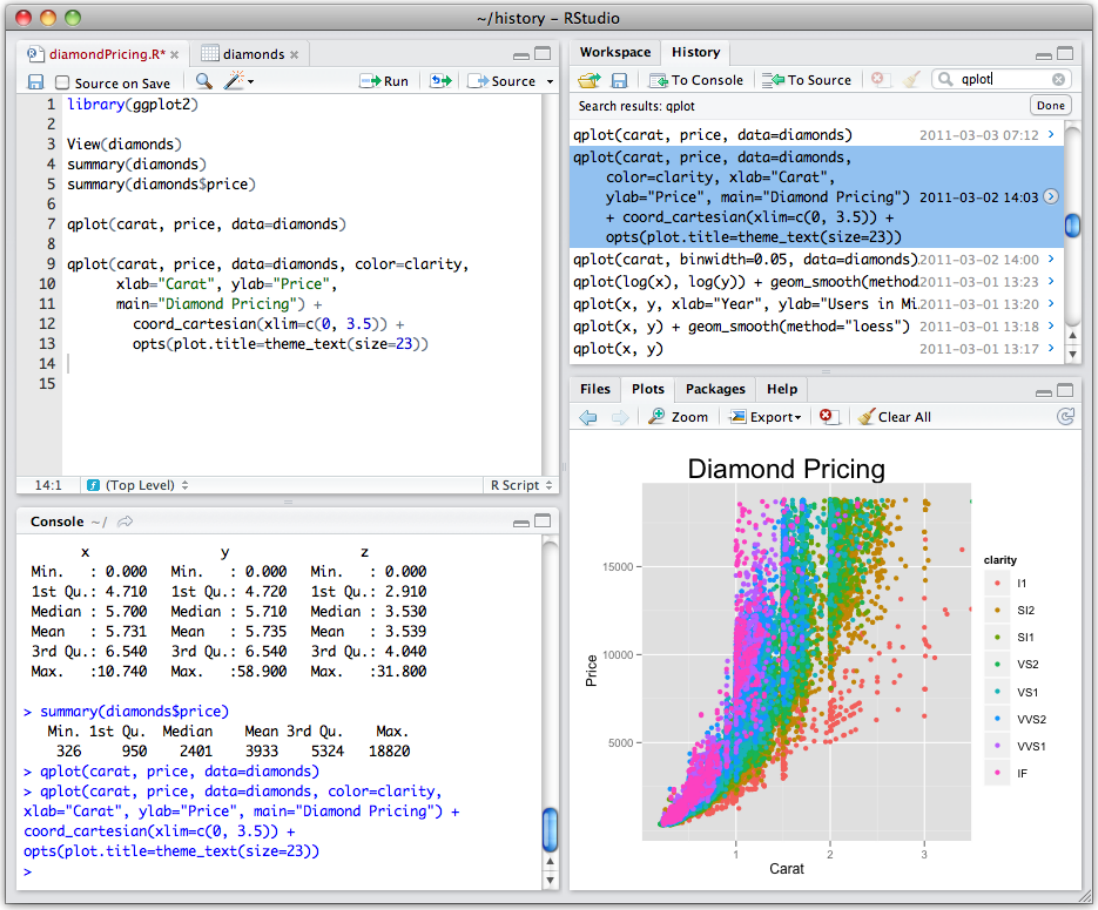
Windows -> http://cran.r-project.org/bin/windows/base/

Mac OS X -> http://cran.r-project.org/bin/macosx/

Linux (Ubuntu) -> http://cran.r-project.org/bin/linux/ubuntu/README

Download Rstudio -> http://www.rstudio.com/products/rstudio/download/

Starting with R



Assignment operators

Assignment operator : **<-**

- *assigns a value to an R-object*

```
> x <- 3 # assigns value 3 to object x
> x
[1] 3
```

```
> x = 3
```

Possible, but may give unexpected results

Arithmetic operators

+, -, /, *, ^

```
> x + x # addition
[1] 6
> x/2 # division
[1] 1.5
> x^2 # exponentiation
[1] 9
```

Relational operators

Comparison of values

```
> x == 3 # x equal to 3
[1] TRUE
> x != 3 # x not equal to 3
[1] FALSE
> x < 3 # x smaller than 3
[1] FALSE
> x >= 3 # x greater or equal to 3
[1] TRUE
```

Data formats: vectors (1)

c(. . .) concatenates numbers into a numeric vector

```
> a <- c(3, 4 ,9) # vector a
> a
[1] 3 4 9
> class(a) # what class of vector?
[1] "numeric"
> length(a) # how many elements?
[1] 3
> a[2] # what is 2nd element of a?
[1] 4
```

Data formats: vectors (2)

c(. . .) also concatenates characters into a character vector

```
> b <- c("cat", "dog")
> b
[1] "cat" "dog"
> class(b)
[1] "character"
> length(b)
[1] 2
> b[2]
[1] "dog"
```

Exercise 1

Run the following commands:

```
> a <- c(3, 4 ,9)
> b <- c("cat", "dog")
> a+3
> b+3
> a*3
> a*a
> a==4
> (a==4)*a
> a>4
> a[a>4]
```

Functions

R-functions have the following structure:

result <- functionname(arg1,arg2, . . .)

- **result** stores the outcome of the function
- **arg1, arg2, . . .** are the arguments of the function
- Some arguments are mandatory, others not (those with default values)

To open help page type:

> ?functionname

Exercise 2

Use functions **length,mean,sum,var** to obtain for vector **a**

a) The number of elements

b) The mean

c) The sum

d) The variance

Use **?length, ?mean, ?sum, ?var** to see help page

Generate vectors (1)

R has several functions to generate vectors

- **seq()** yields a sequence of numbers

seq(from = 1, to = 1, by = ..., length.out = NULL)

Exercise 3

Check help page

> ?seq # for help page

Run these commands and see if you understand them:

> seq(from=1, to=5)

> seq(5)

> 1:5

> seq(1, 5, by=2)

> seq(1, 5, length.out=9)

Generate vectors (2)

rep()repeats numbers and/or vectors

rep(x, times=1, each=1)

- **x** is a number or vector
- **times** is the number of replications of **x** (default = 1)
- **each** is the number of replications of the element of **x** (default = 1)

Exercise 4

Run the following commands and see if you understand:

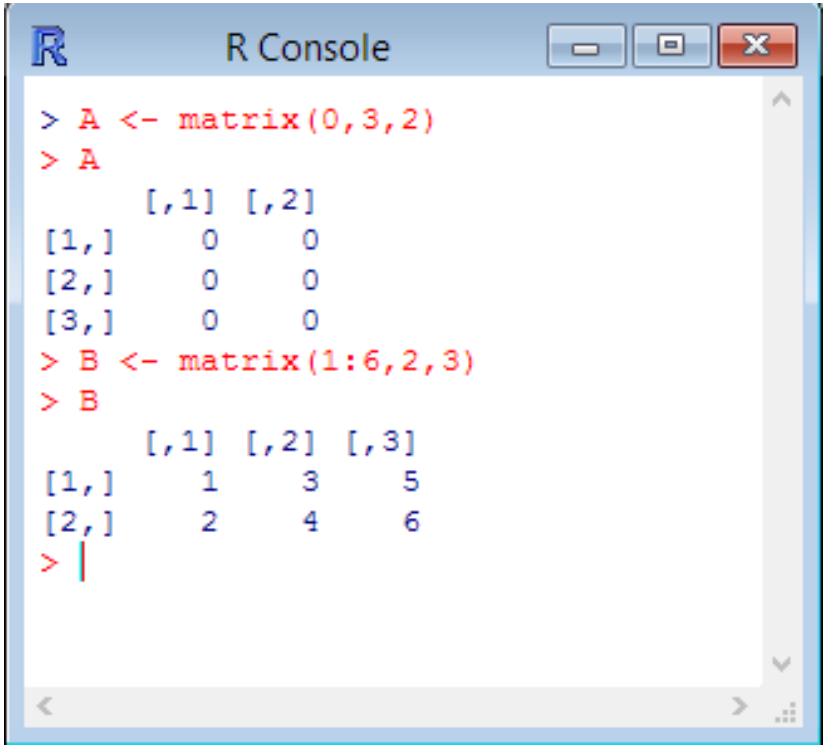
```
> rep(1, times=2)
> rep(1:4, times=2)
> rep(1:4, each=2)
> rep(1:4, times=2, each=2)
> rep(1:4, 1:4)
```

Data formats: matrix

matrix is a 2-dimensional array

matrix(x, nrow=1, ncol=1, byrow=FALSE)

- x can be a number or a vector
- nrow and ncol are dimensions
- Default is filled by column



Matrix computations

R Console

```
> B
     [,1] [,2] [,3]
[1,]    1    3    5
[2,]    2    4    6
> B[1,] # 1st row of B
[1] 1 3 5
> B[2,3] # element in 2nd row, 3rd column
[1] 6
> 2*B+10 # applies to each element of B
     [,1] [,2] [,3]
[1,]   12   16   20
[2,]   14   18   22
> B[,1]<-0 # set 1st column to zero
> B
     [,1] [,2] [,3]
[1,]    0    3    5
[2,]    0    4    6
>
```

Data frames

```
> B
     [,1] [,2] [,3]
[1,]    1    3    5
[2,]    2    4    6
> as.data.frame(B)
  V1 V2 V3
1  1  3  5
2  2  4  6
>
```

Data frame examples

R contains many build-in data sets

- For an overview, type **> data()**
- We will look at **chickwts** (further down the list)

> dataset$variable # extracts the variable

R data sets

```
Data sets in package 'datasets':

AirPassengers
                Monthly Airline Passenger
                Numbers 1949-1960
BJsales         Sales Data with Leading
                Indicator
BJsales.lead (BJsales)
                Sales Data with Leading
                Indicator
BOD             Biochemical Oxygen Demand
CO2             Carbon Dioxide Uptake in
                Grass Plants
ChickWeight     Weight versus age of chicks
                on different diets
DNase           Elisa assay of DNase
```

Data formats: lists

Lists are used to store all kinds of R-objects

- Vectors, matrices, formulas, etc.

R Console

```
> my.list <- list(a=a,b=b,A=A,B=B)
> my.list
$a
[1] 3 4 9

$b
[1] "dog" "cat"

$A
     [,1] [,2]
[1,]    0    0
[2,]    0    0
[3,]    0    0

$B
     [,1] [,2] [,3]
[1,]    0    3    5
[2,]    0    4    6

> |
```

Summarizing data

summary() is a function to summarize R objects (inc. data frames)

> summary(chickwts) # provides a summary of the variables

```
weight          feed
Min. :108.0     casein :12
1st Qu.:204.5   horsebean:10
Median :258.0   linseed :12
Mean :261.3     meatmeal :11
3rd Qu.:323.5   soybean :14
Max. :423.0     sunflower:12
```

Note that R recognizes the class of the variables and summarizes them correctly

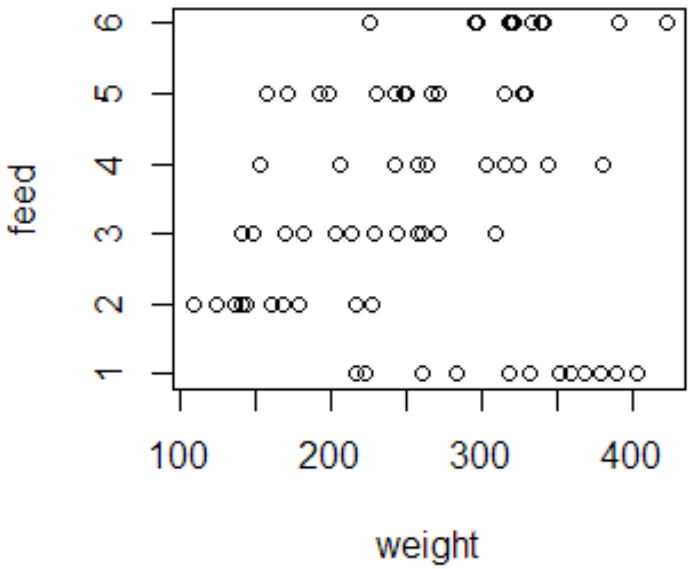
Plotting data

plot()is the basic R-function for making plots

- You can plot a data frame

> plot(chickwts)

- Result is scatter plot
- **feed** treated as numerical



Formulas

Formulas are used to specify statistical models

The operator is the ~ sign

y ~ x # y as a function of x

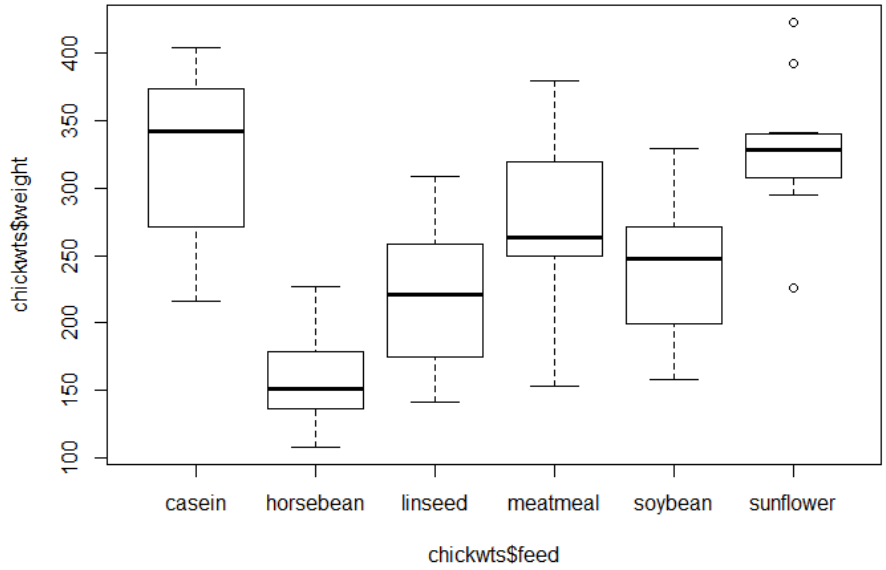
y ~ x + z # y as a function of x and z

y ~ x*z # y as a function of x, z and xz

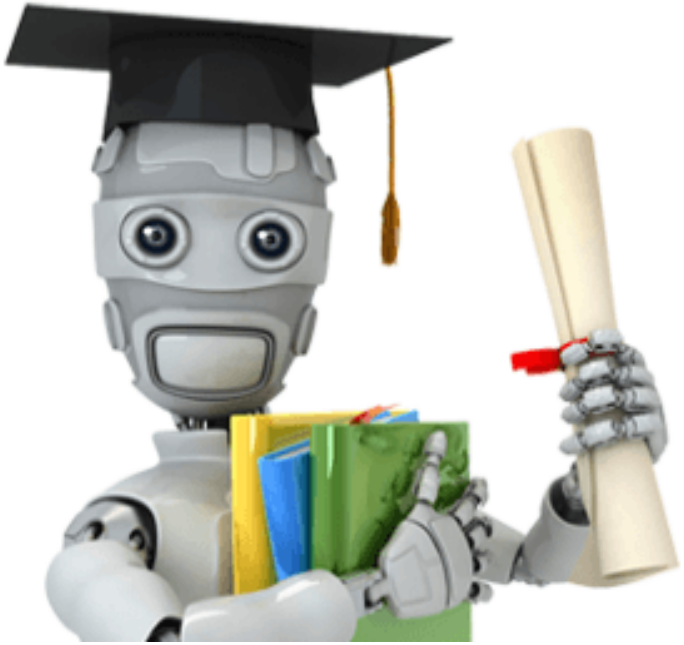
Exercise 6

For the data set **chickwts**

- Plot **weight** as a function of **feed**



Machine Learning



Techniques

- classification: predict class from observations
- clustering: group observations into "meaningful" groups
- regression (prediction): predict value from observations

Classification

- classify a document into a predefined category.
- documents can be text, images
- Some examples: Naive Bayes Classifier, KNN, SVM .

Example:

- Features: Humidity ,Temperature ,Season
- Classifies if it rains or not

Clustering

clustering is the task of grouping a set of objects in such a way that objects in the same group (called a **cluster**) are more similar to each other

objects are not predefined

For e.g. these keywords

- “man’s shoe”
- “women’s shoe”
- “women’s t-shirt”
- “man’s t-shirt”
- can be cluster into 2 categories “shoe” and “t-shirt” or “man” and “women”

Popular ones are **K-means clustering** and **Hierarchical clustering**

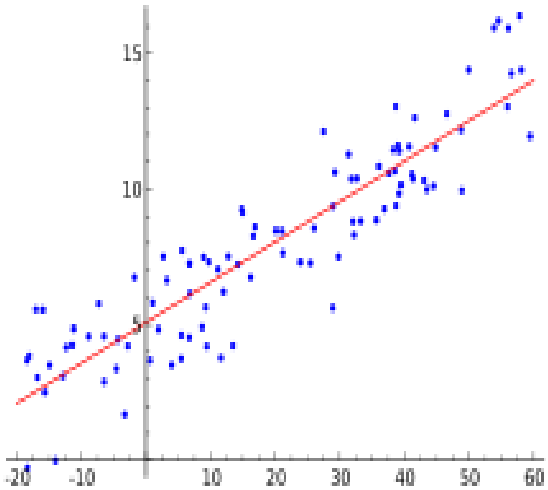
Regression

is a measure of the relation between the mean value of one variable (e.g. output) and corresponding values of other variables (e.g. time and cost).

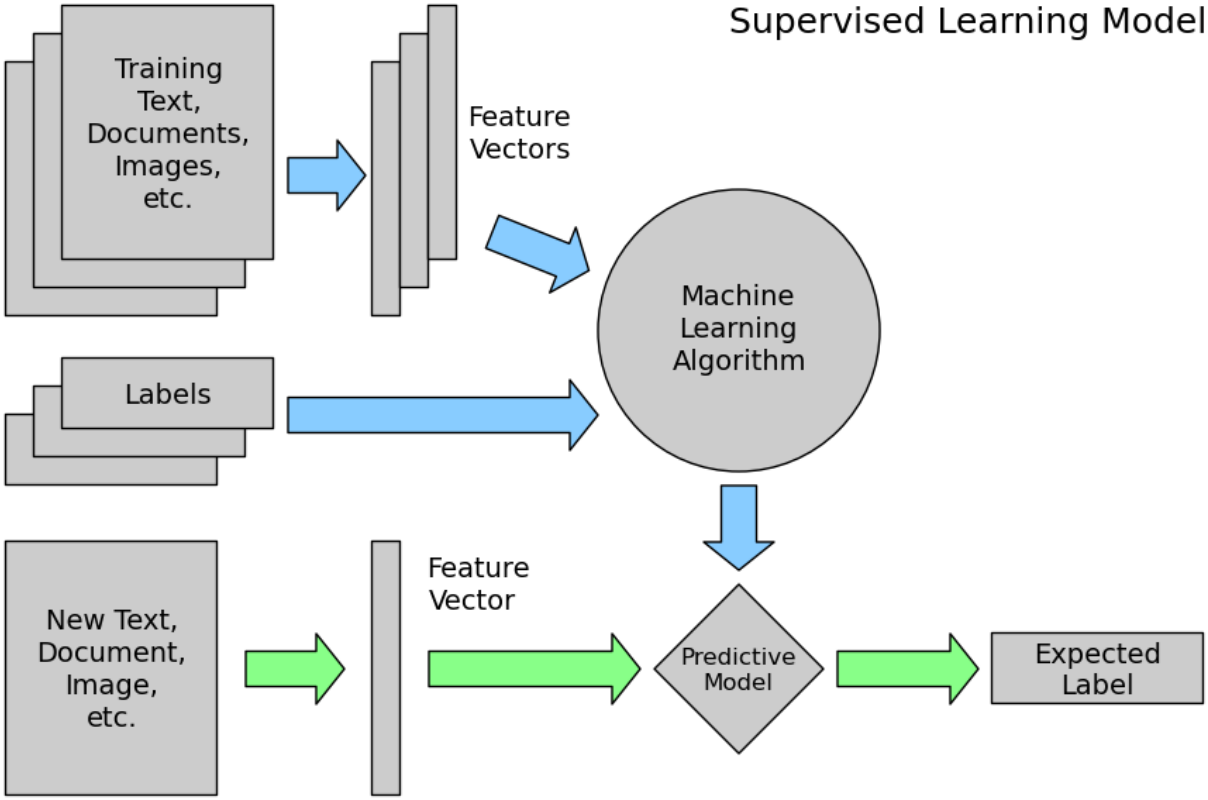
regression analysis is a statistical process for estimating the relationships among variables.

Regression means to **predict** the output value using training data.

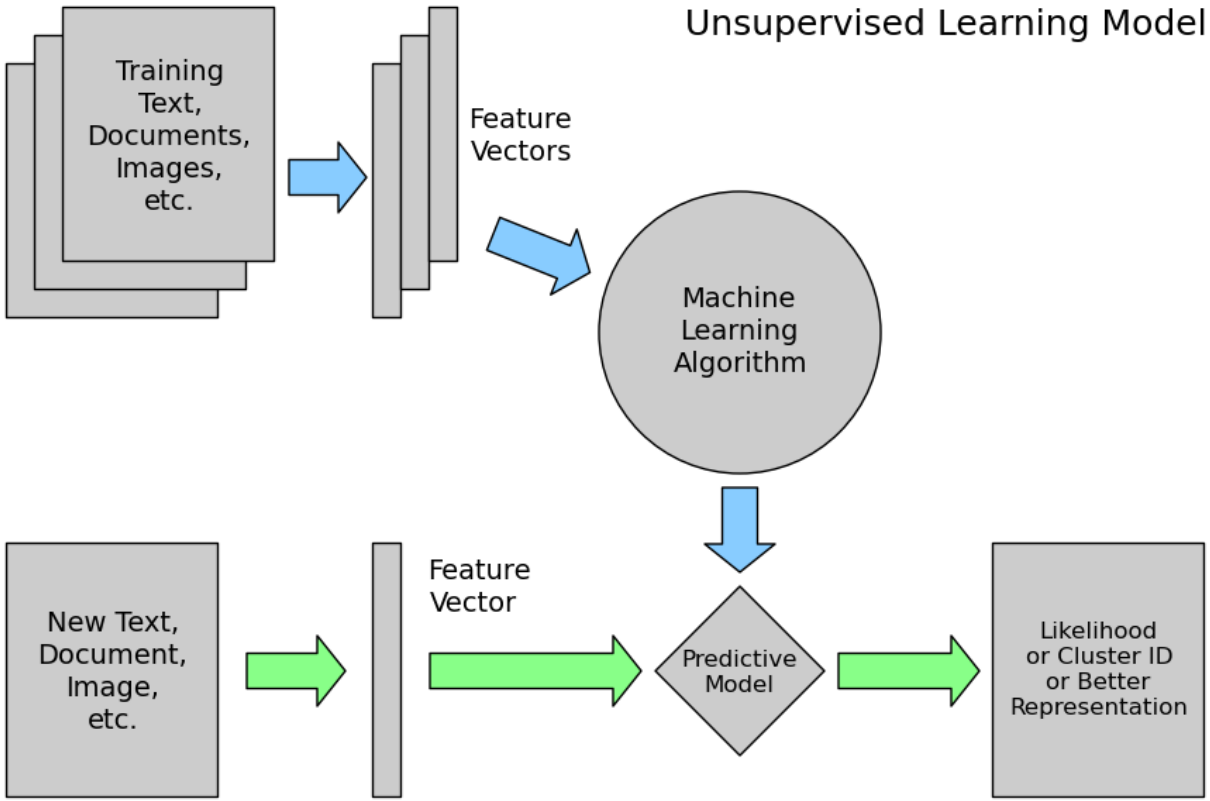
Some examples: Logistic regression (binary regression), artificial neural networks.



Supervised Learning



Unsupervised Learning



Use-Cases

- Spam Email Detection
- Machine Translation (Language Translation)
- Image Search (Similarity)
- Clustering (KMeans) : Amazon Recommendations
- Classification : Google News
- Text Summarization - Google News
- Rating a Review/Comment: Yelp

continued…

Use-Cases (contd.)

- Fraud detection : Credit card Providers
- Decision Making : e.g. Bank/Insurance sector
- Sentiment Analysis
- Speech Understanding – iPhone with Siri
- Face Detection – Facebook's Photo tagging

Example (Age Detection) ->http://how-old.net/

R and Data Mining (example1)

Text Mining

- Find words related to "#word" on Twitter
- Find relationships between words

R and Machine Learning

Regression using Artificial neural networks (ANN)

Problem: Credit scoring

- selecting the correct independent variables (e.g. income, age, gender)
- Variables (clientId, icome, age, loan, LTI- the loan to yearly income ratio, default10yr)
- *creditworthiness=f(income, age, gender, ...)*
- whether or not a default will occur within 10 years?

Exercise

Use infert dataset from default datasets

- Description: infert Infertility after Spontaneous and Induced Abortion
- 248 observations and 8 variables
- Variables: “education”, “age”, “parity”, “induced”, “case”, “spontaneous”, “stratum”, “pooled.stratum”

Formula: case~age+parity+induced+spontaneous

```
## extract a set to train the NN

trainset <- dataset[1:240, ]

## select the test set

testset <- dataset[70:90, ]
```