Introduction to R (Programming)

Thomas Stibor

GSI
Helmholtzzentrum für Schwerionenforschung GmbH

t.stibor@gsi.de

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Literature

Figure: Programmieren mit R, Uwe Ligges, Springer-Verlag.

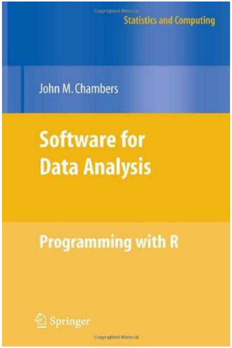


Figure: Software for Data Analysis: Programming with R, John M. Chambers, Springer-Verlag.

http://www.r-project.org/

History

Ross Ihaka and Robert Gentleman. R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics*, 5:299-314, 1996 (`http://www.jstor.org/stable/1390807`).

- R is a language for developing statistical software (open source (GPL)).
- R implements a version of the S language (designed at Bell Laboratories).
- R is a command line interpreter language similar to Perl or Python.
- Large number of packages (CRAN) for a wide range of applications exist (Machine Learning, Genetics, ...)
- Available on large number of platforms: Linux, Mac OS X, Windows, FreeBSD, ...

R command line interpreter

```
stibor@herkules:~>R

R version 2.13.0 (2011-04-13)
Copyright (C) 2011 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: x86_64-unknown-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale
.
.
.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> all.equal((1+1/1000)^1000,exp(1))
[1] "Mean relative difference: 0.0004997918"
```

Run R scripts in batch mode: `R CMD BATCH file.R` or `R --no-save < file.R`

Basic Operations, Functions and Values

operator, function, value	description
^ or **	power
*, /	multiplication, division
max(),min()	maxima, minima
abs()	absolute value
sqrt()	square root
round(), floor(), ceiling()	rounds the values
sum(), product()	sum, product
log(), log10(), log2()	natural logarithm, base 10 log., base 2
exp()	exponential function
sin(), cos(), tan()	trigonometric functions
pi	number π
Inf,-Inf	infinity
NaN	not a number
NA	not available
NULL	null object

Lists, Vectors, Matrices

An R list is an object consisting of an ordered collection of objects known as its components.

```
X <- list(spot.name="Hookipa",
          n.windydays = 320, pi*c(1:10))
names(X)
unlist(X)
sum(unlist(X[3]))
X$spot.name <- "River␣Gorge"
is.list(X)
# use a list to store different type of
# objects (matrices, vectors, scalars, etc.)
list.container <- list(mat = matrix(c(1,2,3,4),nrow=2),
                       vec = c(5,6,7,8), exp(1))
```

Lists, **Vectors**, Matrices

```
vec <- c(1:100)
# sum numbers 1,2,...,100
s <- 0
for(i in 1:length(vec))
  s <- s + vec[i]
# smarter and faster
sum(vec)

s <- 0
for(i in 1:length(vec))
  s <- s + sqrt(log(vec[i]))

sum((log(vec))^(1/2))

# dot product
x <- c(1:10); y <- c(11:20);
as.real(x %*% y)
```

Lists, Vectors, **Matrices**

```r
S <- 1e03
n <- m <- matrix(runif(S*S,min=-10,max=0),nrow=S,ncol=S)
# avoid using for loops
system.time({
for(r in 1:nrow(m))
  for(c in 1:ncol(m))
    m[r,c] <- m[r,c]^2
})
# use apply, mapply, ....
system.time({n <- apply(n, 2, function(x) x^2)})

identical(m,n)
```

Lists, Vectors, **Matrices**

```
m <- matrix(rnorm(20),nrow=4,ncol=5)
# singular-value decomposition
svd.mat <- svd(m)
# reconstruct matrix m
n <- svd.mat$u %*% diag(svd.mat$d) %*% t(svd.mat$v)
all.equal(m,n)

# compute eigenvalues and eigenvectors
eigen(m %*% t(m))

# solve linear eq. system
A <- matrix(c(3,5,1,
              2,7,3,
              4,4,2), byrow=T, nrow=3)
y <- c(3,4,5)
s <- solve(A,y)
s <- as.matrix(s)
A %*% s == y
```

Functions

```
# recursive function
n.choose.k <- function(n,k) {
  if (k == 1)
    return(n)
  if (n == k)
    return(1)
  return( n.choose.k(n-1,k) + n.choose.k(n-1,k-1) )
}

# create 10 random tuples (x1,x2) \in {1,2,...,15}
# and verify whether n.choose.k is correntl y computed
i <- 1;
while(i <= 20) {
  x <- sort(sample(size=2,x=c(1:15)), decreasing = TRUE)
  print(choose(x[1],x[2]) == n.choose.k(x[1],x[2]))
  i <- i + 1;
}
```

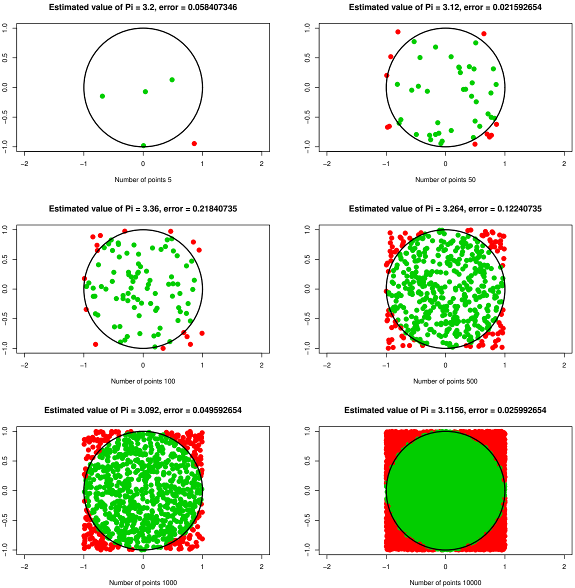
(Some) Distributions in R

Distribution	R name	additional arguments
beta	`beta`	shape1, shape2, ncp
binomial	`binom`	size, prob
Cauchy	`cauchy`	location, scale
chi-squared	`chisq`	df, ncp
exponential	`exp`	rate
gamma	`gamma`	shape, scale
geometric	`geom`	prob
hypergeometric	`hyper`	m, n, k
negative binomial	`nbinom`	size, prob
normal	`norm`	mean, sd
Poisson	`pois`	lambda
uniform	`unif`	min, max
Wilcoxon	`wilcox`	m, n

Approximate π Example

```
N.vec <- c(5,50,100,500,1000,10000);

pdf("pi_estm.pdf", width = 10.0, height = 10.0);
par(mfrow=c(3,2));

for(N in N.vec) {

  x.y.rand <- matrix(runif(2*N, min=-1,max=1),nrow=N,ncol=2);

  bool.in.out <- ((x.y.rand[,1]^2 + x.y.rand[,2]^2) < 1);
  in.circle   <- sum(bool.in.out);

  est.pi <- 4*in.circle/N;
  sprintf("Estimated␣value␣of␣Pi␣is␣%f\n",est.pi);

  text.res <- paste("Estimated␣value␣of␣Pi␣=␣", format(est.pi, digits = 5),
                    ",␣error␣=␣", format(abs(pi-est.pi), digits = 8), sep="");
  text.N   <- paste("Number␣of␣points␣",N,sep="");

  plot(x.y.rand, xlim=c(-1,1), ylim=c(-1,1),
       xlab=text.N, ylab="", main=text.res,
       pch=19, cex=1.5, col=bool.in.out+2, asp=1);

  symbols(x=0, y=0, circles=1, inches=FALSE,
          xlim=c(-1,1), ylim=c(-1,1), add=TRUE, lwd=2);

}

dev.off();
```

Approximate π Example (cont.)



Markov Chain Example

Obtain a sample from a Markov chain specified by initial state vector and transition matrix.

```
States <- LETTERS[1:3] # three states A,B,C
init.pi <- c(0.6, 0.1, 0.3)
names(init.pi) = States

A <- matrix(c(0.2, 0.5, 0.3,
              0.6, 0.2, 0.2,
              0.1, 0.1, 0.8),byrow=T,nrow=3)
dimnames(A) = list(from = States, to = States)

l <- 10; # sample has l states
states <- c()
states <- c(states, sample(States, 1, prob = init.pi))
for (i in 2:l) {
  state = sample(States, 1, prob = A[states[i - 1], ])
  states = c(states, state)
}
```

CRAN Packages

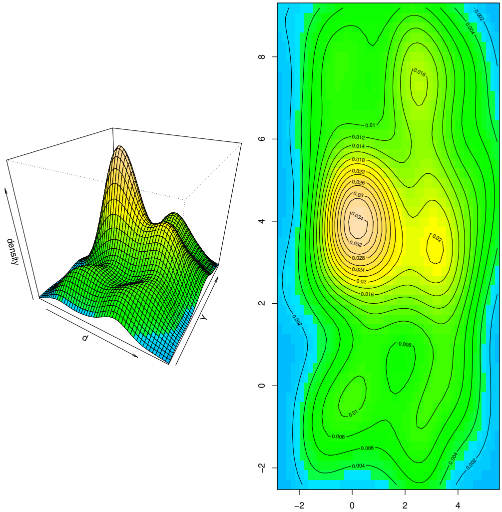
Suppose you want to sample from a Bernoulli distribution.

```
> rbern
```

will not work. However, there exists (for sure) a CRAN package (http://cran.r-project.org/web/packages/).

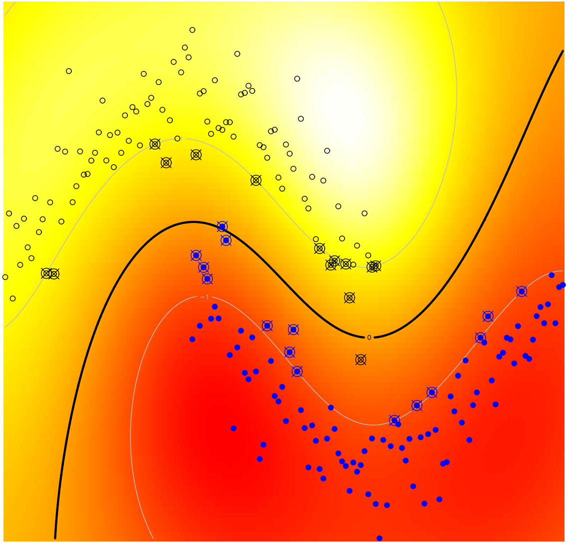
```
> install.packages("Rlab")
* DONE (Rlab)
> library(Rlab)
> rbern(n=10, prob=1/3)
 [1] 0 1 1 0 0 1 0 0 0 1
```

Graphics (Kernel Density Estimator)



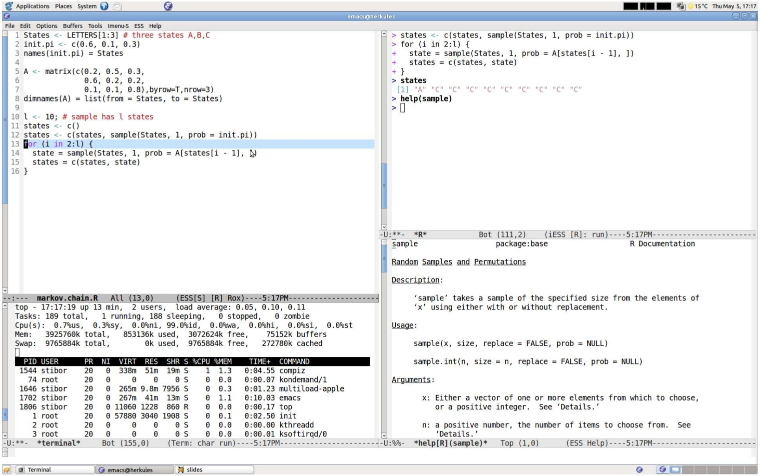
Taken from `http://addictedtor.free.fr/graphiques/`

Visualize SVM Decision Boundary



Environments for R

I personally prefer Emacs and the ESS packages



Good and easy to learn IDE is `http://www.rstudio.org/`.

Summary

R is a very powerful language for data analysis and graphics.

There are tons of features in R, I haven't considered in this brief overview. Go and explore the power and richness of R.

http://www.r-project.org