STA 114: Statistics

Lab 1

This lab work is intended to be an introduction to the software **R.** What follows is a description of the basic functionalities of **R** , along with a series of tasks that you'd have to perform.

What is R

- An interpreter-based programming, graphics and statistics package.
- Free, stable, can be extended.
- Can easily perform standard statistical and numerical analysis.
- Can be programmed to handle non-standard cases.
- For complex tasks, it is often used as a first step to interface with `C` or `FORTRAN`.
- Almost all new statistical methodology is published with a ready to use package built with **R** .

Launching R

- On `UNIX` type workstations, simply type **R** at the prompt.
- On windows open through `Start -> All Programs -> R -> R 2.4.#`
- We will talk about the `UNIX` version, the Windows version is almost identical.
- Once launched **R** prints an opening message (see next page) and gives a command prompt `>`.

```
R version 2.4.1 (2006-12-18)
Copyright (C) 2006 The R Foundation for Statistical Computing
ISBN 3-900051-07-0

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

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

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.

>
```

Entering Commands

- You can directly input commands at the prompt:

```
> 2 + 3
[1] 5
> options(digits = 3)
> rnorm(50)
 [1] -0.0156 -0.3881  1.0899  0.9864  0.1681  0.4718  2.4950 -0.2498  2.0989
[10] -0.5637  0.8308  1.2964  0.7397  0.4435  0.0214  0.4449  0.6374 -1.2289
[19]  0.2015 -0.5251  0.2335  1.0448 -0.0116  0.9199  1.0381 -1.1217  0.7467
[28] -0.2151 -1.0740  0.3098 -0.8013  1.3933 -1.0898 -0.4594 -0.1406 -0.4284
[37] -1.4735  1.7980  1.1085  0.8844  0.1370  0.4474  0.7443 -0.1297  0.4804
[46]  0.1587  1.0659  1.2216  0.0639 -0.0614
```

- If you hit enter befor completely entering a command, you will get a `+` prompt. You must complete the command or type `^C` (`Esc` in MSW) to continue.
- All arithmatic operations are represented via standard symbols (`+ - * /`) and have the usual order of precedence.
- All common functions are represented by their usual names.

Examples

```
> sin(pi/2)
[1] 1
> sqrt(10.34)
[1] 3.215587
> sqrt(1.44e2)
[1] 12
> log(1 + gamma(1))
[1] 0.6931472
> exp(-1/2)
[1] 0.6065307
> 1 + 2 * (log(cos(0.2)) + pi^2)
[1] 20.69894
```

As you can see, nested operations are performed with proper use of parantheses.

> TASK 1. The function call `dbinom(x, n, p)` evaluates the Binomial(n, p) pdf at the value x. Evaluate Binomial$(309, 0.62)$ at $x = 193$.

R objects

- **R** is an objected oriented environment – everything in **R** is an object, named or unnamed.
- Objects created in the workspace can be saved before quitting **R** by choosing appropriate options after you type `q()`.
- Mainly two types of objects
  - Language objects: functions, expressions, formulas.

  - Data objects: all vectors of different size and type (mode).

- Main modes are: numeric, character (string), logical (TRUE/FALSE) and list (a collection of objects of various modes..).

Creating objects

- Vectors of length 1 can be created using the following "assignment" operator

```
> a <- 2.3
> b <- "StatComp"
> c <- TRUE
```

- General vectors are created using the concatenation function `c()` or the sequence operator `seq` or the repeat operator `rep`.

```
> x <- c(1, 2, -1)
> y <- seq(0, 2, 0.2)
> print(y)
 [1] 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
> z <- rep(1,times = 5)
> z
[1] 1 1 1 1 1
```

- An integer sequence with unit increment can be created by using the shortcut `:`.

```
> 1:10
 [1]  1  2  3  4  5  6  7  8  9 10
> -1:4
[1] -1  0  1  2  3  4
> -1:4 + 2
[1] 1 2 3 4 5 6
> -1:(4 + 2)
[1] -1  0  1  2  3  4  5  6
```

  Note the precedence of `:` over arithmetic operators.

TASK 2. Create a vector `p` with elements $0.0, 0.01, 0.02, \cdots, 1.00$. What's the function of the command `p[42]`? Of `p[54:90]`? Of `p[-11]`?

- A matrix is a long vector stored as a rectangle.

```
> print(a <- matrix(1:12,nrow = 4,ncol = 3))
     [,1] [,2] [,3]
[1,]    1    5    9
[2,]    2    6   10
[3,]    3    7   11
[4,]    4    8   12
> (a <- matrix(1:12,4,3,byrow = TRUE))
     [,1] [,2] [,3]
[1,]    1    2    3
[2,]    4    5    6
[3,]    7    8    9
[4,]   10   11   12
```

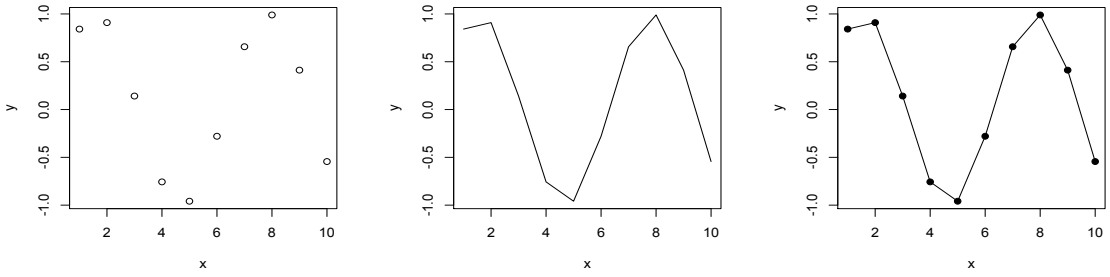
- Higher dimensional arrays can be created as an `array`.

TASK 3. Store the first 100 elements of the vector `p` you created above as a 10×10 matrix `pp`, with the first 10 elements of `p` appearing on the first column of `pp`.
What's the function of the command `pp[42]`? Of `pp[, 4]`? Of `pp[8, ]`? Of `pp[8, 4]`? Of `pp[,-1]`? Of `diag(pp)`?

Plots

- `plot` is the generic function to plot variables. The default use is `plot(x, y)` which plots a vector `y` against another vector `x` provided they have the same length.

```
> x <- 1:10
> y <- sin(1:10)
> plot(x, y)
> plot(x, y, ty = "l")
> plot(x, y, ty = "o", pch = 19)
```



TASK 4. Create a vector `L.comm` that contains the likelihood of the "common" IV study model: $X_{\text{early}} \sim \mathsf{Binomial}(309, p)$ and $X_{\text{delay}} \sim \mathsf{Binomial}(289, p)$ for every element p of the vector `p` you created before, with observation $X_{\text{early}} = 193, X_{\text{delay}} = 203$.
Plot `L.comm` versus `p`, joined by a line.
Use `abline(v = (193 + 203) / (309 + 289), lty = 3)` to draw a vertical line at $x = (193 + 203)/(309 + 289)$. What's the role of `lty`?

Functions

A function is a special kind of **R** object that takes arguments and outputs other objects. The syntax of a function is as follows:

```
f <- function(args){
  body .....
  ...
  return(ans)
 }
```

For example

```
Lik.IV <- function(p.early, p.delay){
  L.early <- dbinom(193, 309, p.early)
  L.delay <- dbinom(203, 289, p.delay)
  return(L.early * L.delay)
 }
```

evaluates that general likelihood of the IV study model at any parameter value `(p.early, p.delay)`.

> TASK 5. Evaluate the above function at (0.62, 0.70), (0.66, 0.66) and (0.70, 0.62).

The `outer` operator

Suppose $f(a, b)$ takes two arguments a and b and we want to evaluate it at every pair of elements (a, b) where a comes from a vector `a` and b comes from a vector `b`. We can simply use `outer(a, b, f)`. Take for example `choose(n, k)` which evaluate $\binom{n}{k}$:

```
> outer(10:13, 1:5, choose)
     [,1] [,2] [,3] [,4] [,5]
[1,]   10   45  120  210  252
[2,]   11   55  165  330  462
[3,]   12   66  220  495  792
[4,]   13   78  286  715 1287
```

> TASK 6. Create a matrix of likelihood values `L.gen` for the general model IV study model: $X_{\text{early}} \sim \mathsf{Binomial}(309, p_{\text{early}})$ and $X_{\text{delay}} \sim \mathsf{Binomial}(289, p_{\text{delay}})$ where each of p_{early} and p_{delay} range over the vector `p` you had created before.

Plotting a matrix

> TASK 7. One can plot the entries of a matrix by using the functions `image` or `contour`. Try the following and see what happens.

```
> image(p, p, L.gen)
> contour(p, p, L.gen)
> image(p, p, L.gen)
> contour(p, p, L.gen, add = TRUE)
> image(p, p, L.gen)
> contour(p, p, L.gen, add = TRUE, nlevels = 4)
> abline(h = 203 / 289, lty = 2)
> abline(v = 193 / 309, lty = 2)
```