BST02: Using R for Statistics in Medical Research

Part C: Functions and Programming

Nicole Erler   Eleni-Rosalina Andrinopoulou

Department of Biostatistics, Erasmus Medical Center

✉ n.erler@erasmusmc.nl   ✉ e.andrinopoulou@erasmusmc.nl

24 - 28 February 2020

Recap Part B

Objects

- `vector`
- `matrix`
- `data.frame`
- `list`

Operators

- +, −, ∗, /
- <-, =
- <, >, ==

Data Structures

- `numeric`
- `character`
- `integer`
- `logical`
- `factor`

Special Values

- `NA`
- `NaN`
- `Inf`, `-Inf`

Data Transformations

- rounding (`format()`)
- convert to factor (`factor()`)

Data Exploration

- `mean()`, `median()`, `sd()`, `IQR()`, ...

Data Visualizations

- plotting packages
- plot types (`plot()`, `barplot()`, ...)

Subsetting

- `[[...]]`, `[...]`, ...

In this Section

- What are functions?
- Useful functions for data exploration
- Useful functions for data manipulations
- Writing functions
- Control-flow constructs
- The `apply` family
- Lots of practicing

Functions

Sometimes we want to perform the same action / manipulation on several objects.

- Option 1: copy & paste
  - a lot of work
  - susceptible to mistakes
- Option 2: **functions**

Functions

Sometimes we want to perform the same action / manipulation on several objects.

- Option 1: copy & paste
  - a lot of work
  - susceptible to mistakes
- Option 2: **functions**

What are functions?

- a group of (organized) R commands
- a (small) programm with flexible (= not pre-specified) input

Almost all commands in R are functions!

Functions

Some examples:

- `mean()`
- `sum()`
- `plot()`
- ...

```
class(mean)
## [1] "function"
class(sum)
## [1] "function"
class(plot)
## [1] "function"
```

Functions

Some examples:

- `mean()`
- `sum()`
- `plot()`
- ...

```
class(mean)
## [1] "function"
class(sum)
## [1] "function"
class(plot)
## [1] "function"
```

Even `class()` is a function:

```
class(class)
```

```
## [1] "function"
```

Useful Functions for Data Exploration

Link to Demo: Functions_DataExploration.R

Link to Practical:

Useful Functions for Data Exploration

Dimension

- `dim()`
- `nrow(), ncol()`
- `length()`

Data Structure

- `str()`
- `names(),`
- `head(), tail()`
- `is.data.frame(), is.list(), is.matrix() is.numeric(), is.ordered(), ...`

Descriptives for Continuous Variables

- `summary()`
- `min(), max(), range()`
- `mean(), median(), quantile(), IQR()`
- `sd(), var()`
- `ave()`

Tables

- `table(), prop.table()`
- `addmargins(), ftable()`

for `matrix` & `data.frame`

- `summary()`
- `var(), cor(), cov2cor()`
- `colSums(), colMeans(), rowSums(), rowMeans()`

Duplicates & Comparison

- `duplicated()`
- `unique()`

Useful functions for Data Manipulation

Link to Demo: Functions_DataManipulation.R

Link to practical

Useful functions for Data Manipulation

Transformations

- `log()`, `log2()`, `log10()`
- `exp()`, `sqrt()`, `plogis()`

Splitting & Combining

- `split()`, `cut()`
- `cbind()`, `rbind()`
- `merge()`
- `subset()`
- `c()`
- `paste()`

repetition & sequence

- `rep()`, `seq()`
- `expand.grid()`

Transformation for objects

- `t()`
- `unlist()`, `unname()`
- `as.numeric()`, `as.matrix()`, `as.data.frame()`

Sorting

- `sort()`, `order()`, `rev()`, `rank()`

matrices

- `%*%`
- `diag()`, `det()`, `solve()`
- `upper.tri()`, `lower.tri()`

Writing Functions

To write your own function:

```r
myfun <- function(arguments) {
  syntax
}
```

For example:

```r
square <- function(x) {
  x^2
}
```

```r
square(3)
```

```
## [1] 9
```

Writing Functions

Functions do not always need an argument:

```
random <- function() {
  rnorm(1)
}
```

```
random()
## [1] 0.3604583
random()
## [1] -2.142618
random()
## [1] -0.6274053
```

Writing Functions

Functions can use multiple arguments:

```r
subtract <- function(x, y) {
  x - y
}
```

```r
subtract(x = 5.2, y = 3.3)
```

```
## [1] 1.9
```

Writing Functions

Multiple arguments are interpretet in the pre-defined order, unless they are named:

```r
subtract(5.2, 1.2)
```

```
## [1] 4
```

```r
subtract(y = 5.2, x = 1.2)
```

```
## [1] -4
```

Writing Functions

We can also define default values for arguments.

```r
multiply <- function(x, y = 2) {
  x * y
}
```

The default value is used when the user does not specify a value for that argument:

```r
multiply(x = 3, y = 3)
```

```
## [1] 9
```

```r
multiply(x = 3)
```

```
## [1] 6
```

Writing Functions

Link to Demo

Link to Practical

Control-flow constructs

- `if(cond) expr`
- `if(cond) cons.expr else (alt.expr)`
- `ifelse()`
- `for`
- `while`
- `repeat`
- `break`
- `next`

What is the apply Family

- Manipulate slices of data from matrices, arrays, lists and dataframes in a repetitive way avoiding explicit use of loop constructs
  - An aggregating function, like for example the mean, or the sum
  - Other transforming or subsetting functions
  - Other vectorized functions, which return more complex structures like lists, vectors, matrices and arrays

What is the apply Family (cont’d)

apply(), lapply() , sapply(), tapply(), mapply()

But how and when should we use these?

How To Use apply() in R

- Operates on Matrices and Data Frames

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 2, sum)
```

```
[1]  6 15  6
```

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 1, sum)
```

```
[1]  6  9 12
```

How To Use apply() in R (cont'd)

- Operates on Matrices and Data Frames

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 2, mean)
```

```
[1] 2 5 2
```

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 1, mean)
```

```
[1] 2 3 4
```

How To Use apply() in R (cont'd)

- You can also apply your functions

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 2, function(x)
          sum(x)/(length(x)-1))
```

```
[1] 3.0 7.5 3.0
```

```r
mat <- matrix(1:6, 3, 3)
mat
```

```
     [,1] [,2] [,3]
[1,]    1    4    1
[2,]    2    5    2
[3,]    3    6    3
```

```r
apply(mat, 1, function(x)
          sum(x)/(length(x)-1))
```

```
[1] 3.0 4.5 6.0
```

How To Use lapply() in R

- Apply a given function to every element of a list and obtain a list as result
- The difference with apply():
  - It can be used for other objects like data frames, lists or vectors
  - The output returned is a list

How To Use lapply() in R (cont’d)

```r
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
myList
```

```
[[1]]
[1] 1 2 3 4 5 6

$y
[1] "m" "f"

$z
[1] 30  4 23
```

```r
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
lapply(myList, length)
```

```
[[1]]
[1] 6

$y
[1] 2

$z
[1] 3
```

How To Use lapply() in R (cont'd)

```r
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
myList
```

```
[[1]]
[1] 1 2 3 4 5 6

$y
[1] "m" "f"

$z
[1] 30  4 23
```

```r
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
lapply(myList, median)
```

```
[[1]]
[1] 3.5

$y
[1] NA

$z
[1] 23
```

How To Use sapply() in R

- sapply() is similar to lapply(), but it tries to simplify the output

```
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
myList
```

```
[[1]]
[1] 1 2 3 4 5 6

$y
[1] "m" "f"

$z
[1] 30  4 23
```

```
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
sapply(myList, length)
```

```
  y z
6 2 3
```

```
sapply(myList, median)
```

```
           y    z
 3.5      NA 23.0
```

How To Use tapply() in R

- Apply a function to subsets of a vector and the subsets are defined by some other vector, usually a factor

```
tapply(pbc$bili, pbc$sex, mean)
```

```
       m        f 
2.865909 3.262567 
```

```
tapply(pbc$age, pbc$sex, median)
```

```
       m        f 
54.00137 50.19302 
```

How To Use tapply() in R (cont'd)

- You can also apply your functions

```r
tapply(pbc$bili, pbc$sex, function(x) sum(x)/(length(x)-1))
```

```
       m        f
2.932558 3.271314
```

How To Use mapply() in R

- Multivariate apply
- Its purpose is to be able to vectorize arguments to a function that is not usually accepting vectors as arguments
- mapply() applies a function to multiple list or multiple vector arguments

```r
mapply(length, pbc)
```

```
      id     time   status      trt      age      sex  ascites   hepato
     418      418      418      418      418      418      418      418
 spiders    edema     bili     chol  albumin   copper alk.phos      ast
     418      418      418      418      418      418      418      418
    trig platelet  protime    stage
     418      418      418      418
```

How To Use mapply() in R (cont'd)

```r
myList <- list(x <- c(1:6),
               y = c("m", "f"),
               z = c(30, 4, 23))
mapply(length, myList, SIMPLIFY = FALSE)
```

```
[[1]]
[1] 6

$y
[1] 2

$z
[1] 3
```