

Introduction to R*

Lecture 3: Control-flow and functions

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1 R Control-flow

1.1 Conditional constructs

- `if`, `else if`, `else`

Syntax:

```
if(condition1){  
  ...  
}[else if(condition2){  
  ...  
}else{  
  ...  
}]
```

- `ifelse()`

The R language provides a **vectorized** version: `ifelse()` .

Syntax:

```
ifelse(condition, vecy, vecn)
```

where:

- *condition* : test condition
- *vecy* : values in case of **TRUE** values
- *vecn* : values in case of **FALSE** values

There exists a more general version of `ifelse()` i.e. `dplyr::case_when()`

1.1.1 Examples

```
score <- 75.0  
  
if(score>=90.0){  
  grade <- 'A'  
} else if((score<90.0) && (score>=80.0)){  
  grade <- 'B'  
} else if((score<80.0) && (score>=70.0)){  
  grade <- 'C'  
} else{  
  grade <- 'D'  
}  
cat(sprintf("Score:%4.2f -> Grade:%s\n", score, grade))
```

Score:75.00 -> Grade:C

```
x <- c(-1,2,1,-5,-7)  
c
```

```
function (...) .Primitive("c")  
res <- ifelse(x>=0, x,-x)  
res
```

```
[1] 1 2 1 5 7
```

1.2 Loop constructs

There are several loop constructs:

- **while**

```
while(condition){  
  body of the loop  
}
```

- **for**

```
for(item in sequence){  
  body of the loop  
}
```

- **repeat**

```
repeat{  
  body of the loop  
}
```

The **repeat** loop has no condition to leave the loop: insert a **break**.

The **break** statement allows one to break out of the **while**, **for** and **repeat** constructs.
The **next** statement allows one to go to the next iteration.

1.2.1 Examples

- for loop construct

```
# Loop over all items  
fruit <- c("apple", "pear", "banana", "grape")  
for(item in fruit){  
  cat(sprintf(" Fruit:%s\n", item))  
}
```

```
Fruit:apple  
Fruit:pear  
Fruit:banana  
Fruit:grape
```

```
# Skip all numbers which are multiples of 3  
x <- sample(1:100, size=10, replace=FALSE)  
x
```

```
[1] 45 73 26 98 41 96 74 88 87 100
```

```

for(item in x){
  if(item%%3==0)
    next
  cat(sprintf(" %3d is NOT a multiple of 3\n", item))
}

```

```

73 is NOT a multiple of 3
26 is NOT a multiple of 3
98 is NOT a multiple of 3
41 is NOT a multiple of 3
74 is NOT a multiple of 3
88 is NOT a multiple of 3
100 is NOT a multiple of 3

```

- while loop

```

x <- sample(1:1000, size=100, replace= FALSE)
isFound <- FALSE
i <- 1
while(!isFound){
  if(x[i]%%7==0){
    cat(sprintf(" %3d is divisible by 7\n", x[i]))
    isFound <- TRUE
  }
  else{
    cat(sprintf(" %3d is NOT divisible by 7\n", x[i]))
    i <- i + 1
  }
}

```

```

3 is NOT divisible by 7
356 is NOT divisible by 7
643 is NOT divisible by 7
140 is divisible by 7

```

- repeat loop

```

i <- 1
repeat{
  # Stop the loop as soon as you find a multiple of 7.
  if(x[i]%%7==0){
    cat(sprintf(" %3d is divisible by 7\n", x[i]))
    break
  }
  else{
    cat(sprintf(" %3d is NOT divisible by 7\n", x[i]))
    i <- i + 1
  }
}

```

```

3 is NOT divisible by 7
356 is NOT divisible by 7

```

643 is NOT divisible by 7
140 is divisible by 7

1.3 Exercises

- Write code to find the smallest of three numbers, e.g. 21, 12, 17
- The **Fibonacci sequence** is defined by the following recurrence relation:

$$F_n = F_{n-1} + F_{n-2}$$

where $F_0 = F_1 = 1$.

Calculate all Fibonacci numbers up to F_{15} .

- The square root of a number n is equivalent to solving the following equation:

$$x^2 - n = 0$$

The solution to this equation can be found iteratively by using e.g. the **Newton-Raphson method**.

Iteration $i + 1$ for x is then given by:

$$x_{i+1} = \frac{1}{2} \left(x_i + \frac{n}{x_i} \right)$$

Find the square root of 751 to a precision of at least 8 decimals. You can set x_0 to n itself.

2 R Functions

2.1 General statements:

The **most common way** to create a function is:

- to assign a function name **and**
- use the **function()** statement

Syntax:

```
function_name <- function(arg_list){  
  # body of the function  
}
```

A function in R has 3 important components:

- arguments of the function: **formals()**
- body of the function: **body()**
- environment in which the function runs: **environment()**

A function can exit in 2 ways:

- by returning a value
 - implicit return: last expression evaluated in the body
 - explicit return: by invoking the **return()** function
- through error e.g. by invoking the **no stop()** function

2.1.1 Examples

- Implicit return

```
a <- 1.0  
b <- 2.0  
mysum1 <- function(x,y){  
  x+y  
}  
cat(sprintf(" Sum of %f and %f is %f\n", a, b, mysum1(a,b)))
```

Sum of 1.000000 and 2.000000 is 3.000000

- Use of an explicit return statement

```
mysum2 <- function(x,y){  
  return(x+y)  
}  
cat(sprintf(" Sum of %f and %f is %f\n", a, b, mysum2(a,b)))
```

Sum of 1.000000 and 2.000000 is 3.000000

- Retrieve the formal arguments of a function

```
formals(mysum2)
```

```
$x
```

```
$y
```

- Retrieve the body of a function

```
body(mysum2)
```

```
{  
  return(x + y)  
}
```

- Retrieve the environment of a function

```
environment(mysum2)
```

```
<environment: R_GlobalEnv>
```

2.2 More on arguments

- default arguments
- varargs

2.3 lazy evaluation of functions

Explain what it means

2.4 piping

discuss library(magrittr)

2.5 prefix vs. infix functions

2.6 anonymous functions

If a function does **not** bear a name it is called an anonymous function see <http://adv-r.had.co.nz/Functional-programming.html#anonymous-functions>

2.7 Exercises

- Write your own factorial function named `myfactorial(n)`.

The factorial function, $n!$ is defined as:

$$n! = n(n-1)!$$

where $0! := 1$.

- Write your own function named `castdie(n)` which simulates casting a die n times.
 - Assume you have a fair die.
 - Adjust the function `castdie(n)` for the general case i.e. a non-fair die.
 - Hint: you can use R's `sample()` function.
- An auto-regressive time series of type AR(1) is defined as follows:

$$x_i = \varphi x_{i-1} + \varepsilon_i$$

where $\varepsilon_i \sim N(0, \sigma^2)$.

- Write the function `genAR1Series(n=1000, x0=0.0, phi=0.7)` which returns the AR(1) time series $\{x_i\}$ for $i \in \{1, \dots, n\}$, where:

$$\begin{aligned} x_0 &= 0.0 \\ \varphi &= 0.7 \\ \varepsilon_i &\sim N(0, 1), \forall i \in \{1, \dots, n\} \end{aligned}$$

- Write the sample autocorrelation function (`myacf(x)`) (ACF) which calculates a vector of $\rho(h)$'s where the `lag` $h \in \{0, 1, 2, \dots, n-1\}$.

The autocorrelation with lag h , i.e. $\rho(h)$ is defined as follows:

$$\rho(h) := \frac{\gamma(h)}{\gamma(0)}$$

where:

$$\begin{aligned} \gamma(h) &:= \frac{1}{n} \sum_{i=1}^{n-h} (x_{i+h} - \bar{x})(x_i - \bar{x}) \\ \bar{x} &:= \frac{1}{n} \sum_{i=1}^n x_i \end{aligned}$$

- Calculate the autocorrelation vector for the time series you generated previously. You can check your results with R's `stats::acf()` function.
- In the cyclic group \mathbb{Z}_4 , we only have the (integer) elements: $\{0, 1, 2, 3\}$. Every addition of $x + y \equiv x + y \pmod{4}$.

```
x <- sample(0:3, size=10, replace=TRUE)
x
```

```
[1] 2 0 2 2 2 3 0 0 2 0
```

```
y <- sample(0:3, size=12, replace=TRUE)
y
```

```
[1] 0 2 3 3 1 2 3 3 3 2 2 0
```

Invoking the infix addition `%+%` results into:

```
res <- x %+% y
```

Warning in `x + y`: longer object length is not a multiple of shorter object length

```
res
```

```
[1] 2 2 1 1 3 1 3 3 1 2 0 0
```

Write an infix function to perform addition in the cyclic group \mathbb{Z}_4 .