Programming Topics II: Writing Functions

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BSDS 100 - Intro to Data Science with `R`

Outline

- What is a function?
- Writing your own functions
- Using functionals

Functions

- We have already used many functions, including `mean()`, `seq()`, `c()`, `data.frame()`, and `ggplot()`
- Just about anything we have used that is followed by parantheses `()` is a function
- Functions tell `R` to perform a specific task

Functions

- Each function has several parts
  1. A name (e.g., `mean`)
  2. A list of arguments often called `formals()`, these can be mandatory (e.g., `mean()` needs a vector of numbers to find the mean of, or optional (e.g., `mean()` can take the argument `na.rm = T`)
  3. A `body()`, which is the code a function executes

Functions

- Recall, we can find a list of a functions arguments with `?`
- Any argument in the documentation followed by `=` carries a default value, that means if the user doesn't fill in that argument, the function can still run using the default (i.e., the argument is optional)
- We can also see the code inside the function by calling it's name without the `()`

Writing a function

- We can write our own functions using assignment and the word "function"

```
name_of_func <- function(arguments_of_function){
body_of_function }
```

- To the left of the function we give it a name, inside the parentheses following the word "function" we list the arguments, and inside the curly brackets we write code
- A simple example

```
my_square <- function(x){
x^2 }
```

Writing a function

- In R whatever the last line of the body to run is what the function will "return", or report to the user
- **Exception!** If the last line of a function body is an assignment the function will return nothing, be sure to avoid this so your function returns something

Writing a function

- Functions are useful because the allow you to repeat the same set of commands without copy and pasting code, which can be error prone and time consuming
- Functions can contain much more complex code than we are showing here, including calling other functions, looping, or if/then statements

Writing a function - Example

- Let's write a function that takes a numeric vector, removes any numbers lower than 1 or higher than 26, then returns the letter of the alphabet that matches each number in the resulting vector

Writing a function - Example

- So far, we have shown functions that take one argument, but functions can also take more than one argument
- This function returns the sum of two numbers a user passes it

```
sum_two <- function(a, b){
a + b }
```

Writing a function - Practice

- Arrange the follow lines to make a function named `subtract_two` that takes two numbers and subtracts the smaller number from the larger number (or returns zero if they are equal)
  - `0`
  - `b - a`
  - `a - b`
  - `subtract_two <- function(a,b){`
  - `if(a == b){`
  - `} else if(a < b){`
  - `} else if(b < a){`
  - `}`
  - `}`
- Test your new function on a couple values to make sure it works!

Writing a function - Practice

- Write a function named `square_df` that takes a vector and returns a data frame with two columns where
  - the first column is named "original" and is the original vector
  - the second column is named "squared" and is each of the elements of the original vector squared
- Test your function on a couple vectors to make sure it works!

Writing a Function - Scoping

- We *could* write a function in the following manner:

```
x <- 1
return_one_two <- function(){
y <- 2
c(x, y)}
```

- Notice how the `x` is written outside of the function even though it is used inside the function?
- But then, what would happen if we forgot to define `x`?

Writing a Function - Scoping

- In this case we would say `x` is **globally** scoped while `y` is **locally** scoped
- We would also say `x` is defined in the **global environment** while `y` is defined in the **local environment**
- Function should be written with all variables locally scoped or passed as arguments to avoid errors
- How would we fix the previous function?

Scoping Practice

- We write a function which returns a number (chosen by the user) divided by 3, we initially write the function like so:

```
 user_chosen_number <- 10
three <- 3
num_divide_three <- function(){
user_chosen_number / three }
```

- Rewrite the function so that the user passes their chosen number as an argument and three is locally scoped

Formal Arguments of a Function

- It is important to distinguish between the formal and actual arguments of a function
- **Formal arguments** are a property of the function

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)

## Default S3 method:
mean(x, trim = 0, na.rm = FALSE, ...)
```

Arguments

`x`	An `R` object. Currently there are methods for numeric/logical vectors and date, date-time and time interval objects. Complex vectors are allowed for `trim = 0`, only.
`trim`	the fraction (0 to 0.5) of observations to be trimmed from each end of `x` before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.
`na.rm`	a logical value indicating whether `NA` values should be stripped before the computation proceeds.
`...`	further arguments passed to or from other methods.

Calling Arguments of a Function

- It is important to distinguish between the formal and actual arguments of a function
- **Actual or calling arguments** can vary each time you call a function

```
> mean(x = 1:10)
[1] 5.5

> mean(x = 99:999)
[1] 549
```

- In the above examples, the calling arguments are `1:10` and `99:999` respectively

Default Arguments

- It is also possible to define default values for your function
- The default values will be used if the user doesn't specify a value

Default Arguments

```
# w/o default values
myFunc_10 <- function(a, b) {
  c(a, b)
}

> myFunc_10()
Error in myFunc_10() : argument "a" is missing, with no default

# with default values
myFunc_11 <- function(a = 1, b = 2) {
  c(a, b)
}

> myFunc_11()
[1] 1 2
```

Default Arguments

Function arguments in R can be defined in terms of other arguments

```
myFunc_12 <- function(a = 1, b = a * 2) {
  c(a, b)
}

> myFunc_12()
[1] 1 2

> myFunc_12(111)
[1] 111 222

> myFunc_12(99, 100)
[1]  99 100
```

Return Values

The last expression evaluated in a function becomes the return value

```
myFunc_18 <- function(xyz) {
  if (xyz < 10) {
    0
  } else {
    10
  }
}

> myFunc_18(5)
[1] 0

> myFunc_18(10)
[1] 10
```

To `return()` or not to `return()`

- The last expression evaluated in a function is the return value
- You can always wrap the final expression in `return()` if you choose
- Using `return()` makes the code very slightly slower
- In simplistic functions, `R` programmers will typically omit `return()`
- In longer, more complicated functions, `return()` is often used when it makes the code easier to read

To `return()` or not to `return()`

```
# simple function, does not require a return()

myFunc_15 <- function(x){
  x + 10
}



# a more complex function benefits visually from having return()
#   but does not require return()

myFunc_18 <- function(xyz) {
  if (xyz < 10) {
    return(0)
  } else {
    return(10)
  }
}
```

Functionals

- In addition to saving you time copying and pasting code, functions can be used with "functionals" to avoid loops
- Because loops (for, while, and repeat) are slow in R avoiding them is useful
- Also, functionals can make your code more readable

Functionals

The `apply()` family of functionals are often used in lieu of *for* loops, coming in a variety of flavors (not exhaustive)

Functional	Input	Output
`apply()`	Array/Matrix	Vector/Array
`lapply()`	Vector/List	List
`sapply()`	Vector/List	List
`vapply()`	Vector/List	Vector

There is also a functional `do.call` which is very flexible and can take and output most types. We will focus on the two most commonly used functionals, `apply()` and `lapply()`

`apply()`

- `apply()` is useful for applying the same function to every row or every column of a matrix
- e.g., `apply(test_matrix, 1, mean)` would find the mean of each row in test_matrix

`apply()`

- What if we want to include `na.rm = T` in our `apply()`?
- Just adding it doesn't work
- Adding it with the placeholder doesn't work
- What should we do?

apply()

- First option, make a custom function, say, `na_mean()` that does what we want
- Second option, make an anonymous or lambda function

```
apply(test_matrix, 1, function(x){mean(x, na.rm = T)})
```

- The anonymous function doesn't have a name, and can't be called again later, but this can be a useful method if you don't anticipate reusing the function

`apply()` practice

- Use `apply()` to get the standard deviation, removing `NA`'s, from the test matrix
- You can either define a new function or use an anonymous function

`lapply()`

- `lapply()` takes and returns a list
- This is useful to us because `R` considers data frames to be a type of list!
- Consider the following:

`lapply()` example

- Assume you are given the following data frame

```
> myDataFrame_01
   A  B C   D   E G
1  1  6 1   5 -99 1
2 10  4 4 -99   9 3
3  7  9 5   4   1 4
4  2  9 3   8   6 8
5  1 10 5   9   8 6
6  6  2 1   3   8 5
```

- Your objective is to replace all of the `-99`s with `NA`s

`lapply()` example

- You could—but shouldn't—iterate through each column manually, e.g.

```
myDataFrame_01$A[myDataFrame_01$A == -99] <- NA
myDataFrame_01$B[myDataFrame_01$B == -99] <- NA
...
myDataFrame_01$F[myDataFrame_01$F == -99] <- NA
```

Problems with Brute-Force Approaches

1. It's easy to make copy-paste mistakes
2. It will take you a really long time
3. If you need to change the code later, you will have to change many lines of code rather than just a few

`lapply()` example

Let's write a function with the objective of replacing all `-99`s in a single column with `NA`s

```
fix99s_byCol <- function(myCol) {
  myCol[myCol == -99] <- NA
}
```

- Will the code above work as intended? Hint: **no**. Why not?

`lapply()` example

Let's write a function with the objective of replacing all `-99`s in a single column with `NA`s

```
fix99s_byCol <- function(myCol) {
  myCol[myCol == -99] <- NA
}
```

- Will the code above work as intended? Hint: **no**. Why not?

`lapply()` example

The following **does** work as intended:

```
fix99s_byCol <- function(myCol) {
  myCol[myCol == -99] <- NA
  myCol
}

myDataFrame_01$A <- fix99s_byCol(myDataFrame_01$A)
...
myDataFrame_01$F <- fix99s_byCol(myDataFrame_01$F)
```

- This reduces but doesn't eliminate the potential for errors
- There is no gain in efficiency (repetitive code is still required)
- We can instead use an `lapply()`

lapply() example

```
fix99s_byCol <- function(myCol) {
  myCol[myCol == -99] <- NA
  myCol
}

> myDataFrame_02 <- lapply(myDataFrame_01, fix99s_byCol)

> str(myDataFrame_02)
List of 6
 $ A: num [1:6] 1 10 7 2 1 6
 $ B: num [1:6] 6 4 9 9 10 2
 $ C: num [1:6] 1 4 5 3 5 1
 $ D: num [1:6] 5 NA 4 8 9 3
 $ E: num [1:6] NA 9 1 6 8 8
 $ F: num [1:6] 1 3 4 8 6 5
```

- This almost worked...but not quite

`lapply()` example

Here are two ways to correct the previous function call so that it returns a data frame

1. `> myDataFrame_03 <- as.data.frame(lapply(myDataFrame_01, fix99s_byCol))`
2. `> myDataFrame_01[] <- lapply(myDataFrame_01, fix99s_byCol)`

Note, option 2 only works when replacing the old data frame with the new values, not for making a brand new data frame

`lapply()` practice

- First, make a function that takes a column and changes all values 4 or smaller to 0 and all values 5 or larger to 10 by filling in the blanks below:

```
big_small <- function(myCol){
myCol[myCol < ___] <- ___
myCol[myCol > ___] <- ___
___ }
```

- Then, use your new function and `lapply()` to change myDataFrame_01 into myDataFrame_0_10, where all the numbers have been transformed to 0s and 10s

End of Class

- On Nov 20 we will cover presentation tips for the final and do a data science wrap-up activity
- No class or Office Hours Nov 22
- Nov 27 will have a function practice lab and time for any last final project work