Lecture 4 Data management: Part I

- Control structure
- Missing value
- Dates
- Useful functions
- How to write our own functions

4.1 Control structure

See ?Control

Avoid using loops in R. I taught a workshop on efficient coding and computing and explaied why. Here is the link: [https://github.com/ly129/MiCM (https://github.com/ly129/MiCM)](https://github.com/ly129/MiCM)

4.1.1 For loop

In [1]:

```
df <- data.frame(names = c("Lucy", "John", "Mark", "Candy"),
                 score = c(67, 56, 87, 91))
df
```

A data.frame: 4 × 2

names	score
<fct>	<dbl>
Lucy	67
John	56
Mark	87
Candy	91

In [2]:

```
for (i in 1:4) {
    df$curved[i] <- sqrt(df$score[i])*10
}
df
```

A data.frame: 4 × 3

names	score	curved
<fct>	<dbl>	<dbl>
Lucy	67	81.85353
John	56	74.83315
Mark	87	93.27379
Candy	91	95.39392

In [3]:

```
x <- NULL
for (i in 1:5) {
    x[i] = 2*i
}
x
```

2 4 6 8 10

4.1.2 While loop

Two useless operators in R that I found useful for teaching: modulus and integer division.

In [4]:

```
9 %% 2    # 9 mod 2
9 %/% 2
```

1

4

Can we write a while loop to do the two operations at the same time?

In [5]:

```
# y %% x
i <- 0
y <- 9
x <- 2
while (y>=x) {
    y <- y - x
    i <- i + 1
}
y   # modulus
i   # integer division
# why?
```

1

4

4.1.3 If, else, ifelse

Not a loop. `ifelse` is the amazing vectorized alternative to `if ..., else, ...`.

Once is enough -

```
-- "Honey, on your way home, buy 6 oranges at the supermar
ket. If they have watermelons, get 1."

-- Mr. Programmer came home with 1 orange.

-- Furious girlfriend, "Why the [--beep--] did you get onl
y 1 orange?"

-- "Because they have watermelons."
```

In [6]:

```
watermelon <- T
no.orange <- if (watermelon == TRUE) {
    "Buy 1 orange"
} else {
    print("Buy 6 oranges")   # As seen in class, print() is usel
ess here.
}
no.orange
```

'Buy 1 orange'

In [7]:

```
# I prefer a simple function, ifelse(test, yes, no)
watermelon <- F
ifelse(watermelon == TRUE, yes = "Buy 1 orange", no = "Buy 6 ora
nges")
```

'Buy 6 oranges'

In [8]:

```
# ifelse is vectorized
df$pass <- ifelse(test = df$score >= 65, yes = TRUE, no = FALSE)
df
```

A data.frame: 4 × 4

names	score	curved	pass
<fct>	<dbl>	<dbl>	<lgl>
Lucy	67	81.85353	TRUE
John	56	74.83315	FALSE
Mark	87	93.27379	TRUE
Candy	91	95.39392	TRUE

4.1.4 Repeat loop

In [9]:

```
i <- 0
repeat {print("Because they have watermelons!")
        i <- i + 1
    if (i>=3){
        break
    }
}
```

```
[1] "Because they have watermelons!"
[1] "Because they have watermelons!"
[1] "Because they have watermelons!"
```

Exercise: use the repeat loop to calculate 9 %% 2 and 9 %/% 2.

In [10]:

```
i <- 0
y <- 9
x <- 2

repeat {
    # The operation
    y <- y - x
    i <- i + 1
    # Stop criteria
    if (y<x) {
        break
    }
}
i; y
```

4

1

Are there any situations that loops cannot be replaced by vector operations?

4.2 Missing values

- NA

In [11]:

```
# Using indices from last lecture to change specific entries in
R objects
df.copy <- df
df.copy$score[2] <- df.copy$names[3] <- NA
df.copy
```

A data.frame: 4 × 4

names	score	curved	pass
<fct>	<dbl>	<dbl>	<lgl>
Lucy	67	81.85353	TRUE
John	NA	74.83315	FALSE
NA	87	93.27379	TRUE
Candy	91	95.39392	TRUE

In [12]:

```
is.na(df.copy)
```

A matrix: 4 × 4 of type lgl

names	score	curved	pass
FALSE	FALSE	FALSE	FALSE
FALSE	TRUE	FALSE	FALSE
TRUE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE

In [13]:

```
# Total number of cells with missing values
sum(is.na(df.copy))
```

2

In [14]:

```
# Whether a data point (row) is complete
complete.cases(df.copy)
```

TRUE FALSE FALSE TRUE

In [15]:

```
!complete.cases(df.copy)
```

FALSE TRUE TRUE FALSE

In [16]:

```
s <- 1:5
s[c(TRUE, FALSE, TRUE, FALSE, FALSE)]
```

1 3

In [17]:

```
# Inomplete data points
df.copy[complete.cases(df.copy), ]
# Recall the logical operator "!"
```

A data.frame: 2 × 4

	names	score	curved	pass
	<fct>	<dbl>	<dbl>	<lgl>
1	Lucy	67	81.85353	TRUE
4	Candy	91	95.39392	TRUE

In [18]:

```
!FALSE
```

TRUE

In [19]:

```
# Taking the average score
mean(df.copy$score)
```

<NA>

In [20]:

```
mean(df.copy$score, na.rm = TRUE)
```

81.6666666666667

In [21]:

```
sum(df.copy$score)
sum(df.copy$score, na.rm = T)
```

<NA>

245

In [22]:

```
na.omit(df.copy)
```

A data.frame: 2 × 4

	names	score	curved	pass
	<fct>	<dbl>	<dbl>	<lgl>
1	Lucy	67	81.85353	TRUE
4	Candy	91	95.39392	TRUE

In [23]:

```
# Options in R that deals with missingness
?na.action
```

4.3 Dates

In [24]:

```
Sys.Date()
# Note the standard date format in R
```

2019-09-26

In [25]:

```
Sys.time() # Eastern Daylight Time
```

```
[1] "2019-09-26 22:29:59 EDT"
```

In [26]:

```
date()
```

'Thu Sep 26 22:29:59 2019'

In [27]:

```
first.hw.post <- as.Date("Oct 4, 2018", tryFormats = "%b %d, %Y"
)
first.hw.post
```

2018-10-04

In [28]:

```
first.hw.due <- as.Date("2018년10월11일", tryFormats = "%Y년%m월%d일
")
first.hw.due
# Just want to show you that any format can be recognized.
# As long as you can let R know how to read it.
```

2018-10-11

In [29]:

```
# Help file: Date-time Conversion Functions to and from Characte
r
# ?strptime
```

In [30]:

```
first.hw.due - Sys.Date()
```

```
Time difference of -350 days
```

In [31]:

```
as.numeric(Sys.Date())
```

18165

In [32]:

```
# Time origin of R
Sys.Date() - as.numeric(Sys.Date())
```

1970-01-01

In [33]:

```
# How long does it take R to load the survival package
time0 <- proc.time()
library(survival)
proc.time() - time0
```

```
   user  system elapsed 
  0.941   0.072   1.136 
```

In [34]:

```
format(Sys.Date(), format = "%A %B %d %Y")
```

'Thursday September 26 2019'

4.4 Useful functions

4.4.1 Numeric functions

In [35]:

```
# Absolute value
abs(-3)
```

3

In [36]:

```
ceiling(3.14159)
```

4

In [37]:

```
floor(3.14159)
```

3

In [38]:

```
trunc(3.14159)
```

3

In [39]:

```
signif(3.14159, 3)
```

3.14

In [40]:

```
round(pi, digits = 10)
```

3.1415926536

Use these functions to calculate 9 %% 2 and 9 %/% 2.

In [41]:

```
trunc(9/2)
```

4

4.4.2 Character functions

- paste( ) and expression( )
    - paste( ) put text and variable values together into a text string.
    - expression( ) can be used to display math symbols when needed, e.g. in plot titles.

Few situations where you have to deal with text in R

- Data frame entries
- Plot title, labels, legends, etc...

In [42]:

```
df
```

A data.frame: 4 × 4

names	score	curved	pass
<fct>	<dbl>	<dbl>	<lgl>
Lucy	67	81.85353	TRUE
John	56	74.83315	FALSE
Mark	87	93.27379	TRUE
Candy	91	95.39392	TRUE

In [43]:

```
for (i in 1:4){
    df$student.no[i] <- paste("student", i)
#     df$curved.score[i] <- round(sqrt(df$score[i]) * 10)
}
```

In [44]:

```
df
```

A data.frame: 4 × 5

names	score	curved	pass	student.no
<fct>	<dbl>	<dbl>	<lgl>	<chr>
Lucy	67	81.85353	TRUE	student 1
John	56	74.83315	FALSE	student 2
Mark	87	93.27379	TRUE	student 3
Candy	91	95.39392	TRUE	student 4

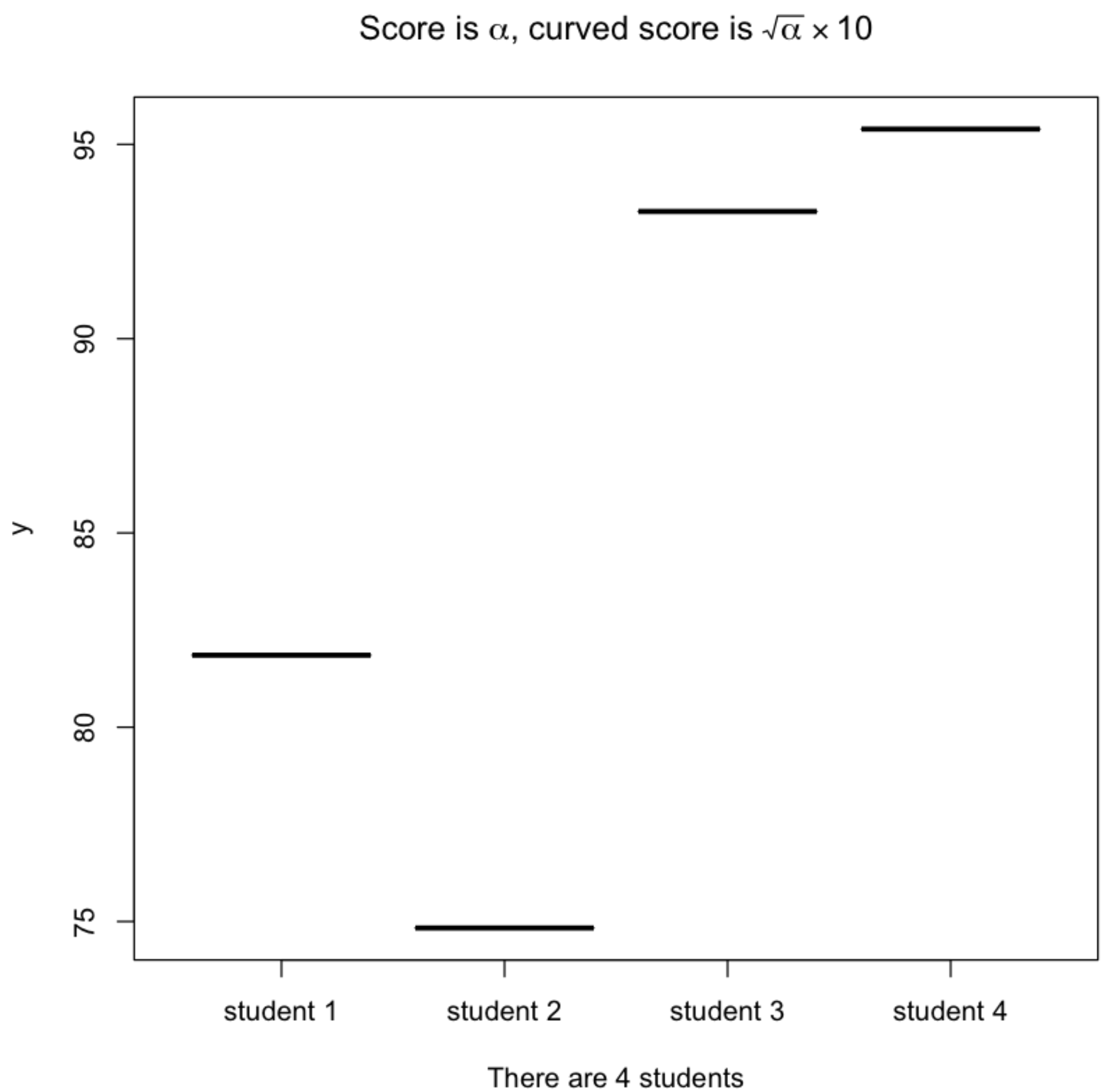
In [45]:

```
str(df)
```

```
'data.frame':	4 obs. of  5 variables:
 $ names     : Factor w/ 4 levels "Candy","John",..:
3 2 4 1
 $ score     : num  67 56 87 91
 $ curved    : num  81.9 74.8 93.3 95.4
 $ pass      : logi  TRUE FALSE TRUE TRUE
 $ student.no: chr  "student 1" "student 2" "student
3" "student 4"
```

In [46]:

```
n <- nrow(df)
plot(as.factor(df$student.no), df$curved,
     # Math symbols in text
     main = expression(paste("Score is ", alpha, ", curved score
is ", sqrt(alpha)%*%10)),
     # Variable value in text
     xlab = paste("There are", n, "students"))
```



4.4.3 `apply` family functions

Some say that apply( ) family functions distinguish R experts and newbies.

Again, much more in my workshop https://github.com/ly129/MiCM (https://github.com/ly129/MiCM).

apply( )

In [47]:

```
df.scores <- df[, c("score", "curved")]; df.scores
```

A data.frame: 4 × 2

score	curved
<dbl>	<dbl>
67	81.85353
56	74.83315
87	93.27379
91	95.39392

In [48]:

```
apply(df.scores, MARGIN = 2, FUN = mean)
```

score
75.25
curved
86.3385965316965

In [49]:

```
apply(df.scores, MARGIN = 1, FUN = diff)   # diff() calculates t
he difference - see Section 4.4.4
```

14.8535277187245   18.8331477354788   6.27379053088816
4.39392014169457

In [50]:

```
myarray <- array(1:12, dim = c(2,3,2)); print(myarray)
```

```
, , 1

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

, , 2

     [,1] [,2] [,3]
[1,]    7    9   11
[2,]    8   10   12
```

In [51]:

```
apply(myarray, MARGIN = c(2, 3), sum)
```

A matrix:
3 × 2 of
type int

3	15
7	19
11	23

sapply( )

In [52]:

```
df
```

A data.frame: 4 × 5

names	score	curved	pass	student.no
<fct>	<dbl>	<dbl>	<lgl>	<chr>
Lucy	67	81.85353	TRUE	student 1
John	56	74.83315	FALSE	student 2
Mark	87	93.27379	TRUE	student 3
Candy	91	95.39392	TRUE	student 4

In [53]:

```
sapply(df, is.numeric)
```

names
FALSE
score
TRUE
curved
TRUE
pass
FALSE
student.no
FALSE

There is also lapply( ), tapply( ), etc...

And their parallel versions mclapply( ), parLapply( ) in the 'parallel' package for parallel computing.

4.4.4 Other useful functions

In [54]:

```
age=c(1,6,4,5,8,5,4,3)
weight=c(45,65,34)
age
```

1 6 4 5 8 5 4 3

In [55]:

```
mean(age)
```

4.5

In [56]:

```
prod(age)
```

57600

In [57]:

```
median(age)
```

4.5

In [58]:

```
var(age)
sd(age)
```

4.28571428571429

2.07019667802706

In [59]:

```
max(age)
min(age)
range(age)
```

8

1

1 8

In [60]:

```
which.max(age)   #returns the index of the greatest element of x
which.min(age)   #returns the index of the smallest element of x
```

5

1

In [61]:

```
seq(from = 0, to = 1, by = 0.25)
quantile(1:100, probs = seq(from = 0, to = 1, by = 0.25))
# Returns the specified quantiles.
```

0 0.25 0.5 0.75 1

0%
1
25%
25.75
50%
50.5
75%
75.25
100%
100

In [62]:

```
age
unique(age)    # Gives the vector of distinct values
```

1 6 4 5 8 5 4 3

1 6 4 5 8 3

In [63]:

```
diff(age)    # Replaces a vector by the vector of first differenc
es
```

5 -2 1 3 -3 -1 -1

In [64]:

```
sort(age, decreasing = F)    # Sorts elements into order
```

1 3 4 4 5 5 6 8

In [65]:

```
order(age)
age[order(age)]    # x[order(x)] orders elements of x
```

1 8 3 7 4 6 2 5

1 3 4 4 5 5 6 8

In [66]:

```r
age
cumsum(age)     # Cumulative sums
cumprod(age)    # Cumulative products
```

1 6 4 5 8 5 4 3

1 7 11 16 24 29 33 36

1 6 24 120 960 4800 19200 57600

In [67]:

```r
cat <- cut(age, breaks = c(-Inf, 2.5, 5.5, Inf))  # Divide conti
nuous variable in factor with n levels
cbind(age, cat)
table(cat)
```

A matrix: 8 × 2 of type dbl

age	cat
1	1
6	3
4	2
5	2
8	3
5	2
4	2
3	2

```
cat
(-Inf,2.5]  (2.5,5.5] (5.5, Inf]
         1          5          2
```

In [68]:

```
# Split the variable into categories
age.cat <- split(age, cat)
age.cat
```

$`(-Inf,2.5]`

1

$`(2.5,5.5]`

4 5 5 4 3

$`(5.5, Inf]`

6 8

In [69]:

```
# split() gives a list
str(age.cat)
```

```
List of 3
 $ (-Inf,2.5]: num 1
 $ (2.5,5.5] : num [1:5] 4 5 5 4 3
 $ (5.5, Inf]: num [1:2] 6 8
```

In [70]:

```
# lapply: list apply
lapply(age.cat, mean)
```

$`(-Inf,2.5]`

1

$`(2.5,5.5]`

4.2

$`(5.5, Inf]`

7

4.5 Write our own functions

- function( )

In [71]:

```
# The structure

func_name <- function(argument) {
    statement
}
```

Write my own function of x^y:

In [72]:

```
X.to.the.power.of.Y <- function(y, x){
    x^y
}
X.to.the.power.of.Y(x = 3, y = 2)
X.to.the.power.of.Y(3, 2)     # Following a question in class, n
ote the difference.
```

9

8

Uses:

- If we need to do some operation a lot later.
- Work with apply( ) family.
    - The 'FUN' argument in apply( ) family functions only take the name of the functions only.
    - No arguments, operators or combinations of these allowed.

Example: calculate the square of the score

In [73]:

```
df.scores
```

A data.frame: 4 × 2

score	curved
<dbl>	<dbl>
67	81.85353
56	74.83315
87	93.27379
91	95.39392

In [74]:

```
# The following code does not work
# apply(df.scores, MARGIN = 2, FUN = ^2)
```

In [75]:

```
# Instead we can do
my.fun <- function(x){x^2}
apply(df.scores, MARGIN = 2, FUN = my.fun)
```

A matrix: 4 × 2 of type dbl

score	curved
4489	6700
3136	5600
7569	8700
8281	9100

Exercise: write our own function to calculate x %% y and x %/% y.

- Note how to return the output in function( ) and assess the results correspondingly.

In [76]:

```
# Two inputs, y and x, so two arguments

# Option 1 - use %% and %/% operators
modulus1 <- function(y, x){
    mod <- y %% x
    int.div <- y %/% x
    return(list(modulus=mod, integer.division=int.div))
}
out1 <- modulus1(y = 9, x = 2)
# print(out1)
out1
str(out1)
```

$modulus

1

$integer.division

4

```
List of 2
 $ modulus         : num 1
 $ integer.division: num 4
```

In [77]:

```
out1$modulus
# out1$integer.division
```

1

In [78]:

```
out1$integer.division
```

4

In [79]:

```
# Option 2 - use trunc() or floor()

modulus2 <- function(y, x){
    mod <- trunc(y/x)      # or floor(y/x)
    int.div <- y - x * mod
    return(c(modulus=mod, integer.division=int.div))
}
out2 <- modulus2(9, 2)
print(out2)
str(out2)
```

```
         modulus integer.division
               4                1
 Named num [1:2] 4 1
 - attr(*, "names")= chr [1:2] "modulus" "integer.di
vision"
```

In [80]:

```
out2[1]
out2[2]
```

modulus: 4

integer.division: 1

In [81]:

```
out2["modulus"]
```

modulus: 4

In [82]:

```
attr(out2, "names")
```

'modulus' 'integer.division'

In [83]:

```
# Option 3 - use loops

modulus3 <- function(y, x){
    i <- 0
    while (y>=x){
        y <- y - x
        i <- i + 1
    }
    return(cat("modulus=", y, ", Integer division=", i)) # modul
us
}

# I want modulus(y, x) to give me 'y mod x' for any integers y a
nd x.
out3 <- modulus3(9, 2)

# Note that without printing out3, the result is already shown.
```

```
modulus= 1 , Integer division= 4
```

In [84]:

```
9%%2
```

1

In [85]:

```
9%/%2
```

4

In [ ]:

```

```