Data Classes

Introduction to R for Public Health Researchers

## Data Classes:

* One dimensional classes ('vectors'):
  + Character: strings or individual characters, quoted
  + Numeric: any real number(s)
  + Integer: any integer(s)/whole numbers
  + Factor: categorical/qualitative variables
  + Logical: variables composed of TRUE or FALSE
  + Date/POSIXct: represents calendar dates and times

## Character and numeric

We have already covered character and numeric classes.

class(c("Andrew", "Jaffe"))

## [1] "character"

class(c(1, 4, 7))

## [1] "numeric"

## Integer

Integer is a special subset of numeric that contains only whole numbers

A sequence of numbers is an example of the integer class

x = seq(from = 1, to = 5) # seq() is a function  
x

## [1] 1 2 3 4 5

class(x)

## [1] "integer"

## Integer

The colon : is a shortcut for making sequences of numbers

It makes consecutive integer sequence from [num1] to [num2] by 1

1:5

## [1] 1 2 3 4 5

## Logical

logical is a class that only has two possible elements: TRUE and FALSE

x = c(TRUE, FALSE, TRUE, TRUE, FALSE)  
class(x)

## [1] "logical"

is.numeric(c("Andrew", "Jaffe"))

## [1] FALSE

is.character(c("Andrew", "Jaffe"))

## [1] TRUE

## Logical

Note that logical elements are NOT in quotes.

z = c("TRUE", "FALSE", "TRUE", "FALSE")  
class(z)

## [1] "character"

as.logical(z)

## [1] TRUE FALSE TRUE FALSE

Bonus: sum() and mean() work on logical vectors - they return the total and proportion of TRUE elements, respectively.

sum(as.logical(z))

## [1] 2

## General Class Information

There are two useful functions associated with practically all R classes, which relate to logically checking the underlying class (is.CLASS\_()) and coercing between classes (as.CLASS\_()).

is.numeric(c("Andrew", "Jaffe"))

## [1] FALSE

is.character(c("Andrew", "Jaffe"))

## [1] TRUE

## General Class Information

There are two useful functions associated with practically all R classes, which relate to logically checking the underlying class (is.CLASS\_()) and coercing between classes (as.CLASS\_()).

as.character(c(1, 4, 7))

## [1] "1" "4" "7"

as.numeric(c("Andrew", "Jaffe"))

## Warning: NAs introduced by coercion

## [1] NA NA

## Factors

A factor is a special character vector where the elements have pre-defined groups or 'levels'. You can think of these as qualitative or categorical variables:

x = factor(c("boy", "girl", "girl", "boy", "girl"))  
x

## [1] boy girl girl boy girl  
## Levels: boy girl

class(x)

## [1] "factor"

Note that levels are, by default, in alphanumerical order.

## Factors

Factors are used to represent categorical data, and can also be used for ordinal data (ie categories have an intrinsic ordering)

Note that R reads in character strings as factors by default in functions like read.table()

'The function factor is used to encode a vector as a factor (the terms 'category' and 'enumerated type' are also used for factors). If argument ordered is TRUE, the factor levels are assumed to be ordered.'

factor(x = character(), levels, labels = levels,  
 exclude = NA, ordered = is.ordered(x))

## Factors

Suppose we have a vector of case-control status

cc = factor(c("case","case","case",  
 "control","control","control"))  
cc

## [1] case case case control control control  
## Levels: case control

levels(cc) = c("control","case")  
cc

## [1] control control control case case case   
## Levels: control case

## Factors

Note that the levels are alphabetically ordered by default. We can also specify the levels within the factor call

casecontrol = c("case","case","case","control",  
 "control","control")  
factor(casecontrol, levels = c("control","case") )

## [1] case case case control control control  
## Levels: control case

factor(casecontrol, levels = c("control","case"),   
 ordered=TRUE)

## [1] case case case control control control  
## Levels: control < case

## Factors

Factors can be converted to numeric or character very easily

x = factor(casecontrol,  
 levels = c("control","case") )  
as.character(x)

## [1] "case" "case" "case" "control" "control" "control"

as.numeric(x)

## [1] 2 2 2 1 1 1

## Factors

However, you need to be careful modifying the labels of existing factors, as its quite easy to alter the meaning of the underlying data.

xCopy = x  
levels(xCopy) = c("case", "control") # wrong way  
xCopy

## [1] control control control case case case   
## Levels: case control

as.character(xCopy) # labels switched

## [1] "control" "control" "control" "case" "case" "case"

as.numeric(xCopy)

## [1] 2 2 2 1 1 1

## Creating categorical variables

The rep() ["repeat"] function is useful for creating new variables

bg = rep(c("boy","girl"),each=50)  
head(bg)

## [1] "boy" "boy" "boy" "boy" "boy" "boy"

bg2 = rep(c("boy","girl"),times=50)  
head(bg2)

## [1] "boy" "girl" "boy" "girl" "boy" "girl"

length(bg) == length(bg2)

## [1] TRUE

## Creating categorical variables

One frequently-used tool is creating categorical variables out of continuous variables, like generating quantiles of a specific continuously measured variable.

A general function for creating new variables based on existing variables is the ifelse() function, which "returns a value with the same shape as test which is filled with elements selected from either yes or no depending on whether the element of test is TRUE or FALSE."

ifelse(test, yes, no)  
  
# test: an object which can be coerced  
 to logical mode.  
# yes: return values for true elements of test.  
# no: return values for false elements of test.

## Charm City Circulator data

Please download the Charm City Circulator data:

<http://www.aejaffe.com/summerR_2016/data/Charm_City_Circulator_Ridership.csv>

# paste/paste0 will be covered later  
circ = read.csv(  
 paste0("http://www.aejaffe.com/summerR\_2016/data",  
 "/Charm\_City\_Circulator\_Ridership.csv"),   
 header = TRUE, as.is = TRUE)

## Creating categorical variables

For example, we can create a new variable that records whether daily ridership on the Circulator was above 10,000.

hi\_rider = ifelse(circ$daily > 10000, "high", "low")  
hi\_rider = factor(hi\_rider, levels = c("low","high"))  
head(hi\_rider)

## [1] low low low low low low  
## Levels: low high

table(hi\_rider)

## hi\_rider  
## low high   
## 740 282

## Creating categorical variables

You can also nest ifelse() within itself to create 3 levels of a variable.

riderLevels = ifelse(circ$daily < 10000, "low",   
 ifelse(circ$daily > 20000,  
 "high", "med"))  
riderLevels = factor(riderLevels,   
 levels = c("low","med","high"))  
head(riderLevels)

## [1] low low low low low low  
## Levels: low med high

table(riderLevels)

## riderLevels  
## low med high   
## 740 280 2

## Creating categorical variables

However, it's much easier to use cut() to create categorical variables from continuous variables.

'cut divides the range of x into intervals and codes the values in x according to which interval they fall. The leftmost interval corresponds to level one, the next leftmost to level two and so on.'

cut(x, breaks, labels = NULL, include.lowest = FALSE,   
 right = TRUE, dig.lab = 3,  
 ordered\_result = FALSE, ...)

## Creating categorical variables

x: a numeric vector which is to be converted to a factor by cutting.

breaks: either a numeric vector of two or more unique cut points or a single number (greater than or equal to 2) giving the number of intervals into which x is to be cut.

labels: labels for the levels of the resulting category. By default, labels are constructed using "(a,b]" interval notation. If labels = FALSE, simple integer codes are returned instead of a factor.

## Cut

Now that we know more about factors, cut() will make more sense:

x = 1:100  
cx = cut(x, breaks=c(0,10,25,50,100))  
head(cx)

## [1] (0,10] (0,10] (0,10] (0,10] (0,10] (0,10]  
## Levels: (0,10] (10,25] (25,50] (50,100]

table(cx)

## cx  
## (0,10] (10,25] (25,50] (50,100]   
## 10 15 25 50

## Cut

We can also leave off the labels

cx = cut(x, breaks=c(0,10,25,50,100), labels=FALSE)  
head(cx)

## [1] 1 1 1 1 1 1

table(cx)

## cx  
## 1 2 3 4   
## 10 15 25 50

## Cut

Note that you have to specify the endpoints of the data, otherwise some of the categories will not be created

cx = cut(x, breaks=c(10,25,50), labels=FALSE)  
head(cx)

## [1] NA NA NA NA NA NA

table(cx)

## cx  
## 1 2   
## 15 25

table(cx,useNA="ifany")

## cx  
## 1 2 <NA>   
## 15 25 60

## Date

You can convert date-like strings in the Date class (<http://www.statmethods.net/input/dates.html> for more info)

head(sort(circ$date))

## [1] "01/01/2011" "01/01/2012" "01/01/2013" "01/02/2011" "01/02/2012"  
## [6] "01/02/2013"

# creating a date for sorting  
circ$newDate <- as.Date(circ$date, "%m/%d/%Y")  
head(circ$newDate)

## [1] "2010-01-11" "2010-01-12" "2010-01-13" "2010-01-14" "2010-01-15"  
## [6] "2010-01-16"

range(circ$newDate)

## [1] "2010-01-11" "2013-03-01"

## Date

However, the lubridate package is much easier for generating explicit dates:

library(lubridate) # great for dates!  
circ = mutate(circ, newDate2 = mdy(date))  
head(circ$newDate2)

## [1] "2010-01-11" "2010-01-12" "2010-01-13" "2010-01-14" "2010-01-15"  
## [6] "2010-01-16"

range(circ$newDate2) # gives you the range of the data

## [1] "2010-01-11" "2013-03-01"

## POSIXct

The POSIXct class is like a more general date format (with hours, minutes, seconds).

theTime = Sys.time()  
theTime

## [1] "2017-01-04 21:33:57 EST"

class(theTime)

## [1] "POSIXct" "POSIXt"

theTime + as.period(20, unit = "minutes") # the future

## [1] "2017-01-04 21:53:57 EST"

## Data Classes:

* Two dimensional classes:
  + data.frame: traditional 'Excel' spreadsheets
    - Each column can have a different class, from above
  + Matrix: two-dimensional data, composed of rows and columns. Unlike data frames, the entire matrix is composed of one R class, e.g. all numeric or all characters.

## Matrices

n = 1:9   
n

## [1] 1 2 3 4 5 6 7 8 9

mat = matrix(n, nrow = 3)  
mat

## [,1] [,2] [,3]  
## [1,] 1 4 7  
## [2,] 2 5 8  
## [3,] 3 6 9

## Matrix (and Data frame) Functions

These are in addition to the previous useful vector functions:

* nrow() displays the number of rows of a matrix or data frame
* ncol() displays the number of columns
* dim() displays a vector of length 2: # rows, # columns
* colnames() displays the column names (if any) and rownames() displays the row names (if any)

## Data Selection

Matrices have two "slots" you can use to select data, which represent rows and columns, that are separated by a comma, so the syntax is matrix[row,column]. Note you cannot use dplyr functions on matrices.

mat[1, 1] # individual entry: row 1, column 1

## [1] 1

mat[1, ] # first row

## [1] 1 4 7

mat[, 1] # first columns

## [1] 1 2 3

## Data Selection

Note that the class of the returned object is no longer a matrix

class(mat[1, ])

## [1] "integer"

class(mat[, 1])

## [1] "integer"

## Data Frames

To review, the data.frame is the other two dimensional variable class.

Again, data frames are like matrices, but each column is a vector that can have its own class. So some columns might be character and others might be numeric, while others maybe a factor.

## Lists

* One other data type that is the most generic are lists.
* Can be created using list()
* Can hold vectors, strings, matrices, models, list of other list, lists upon lists!
* Can reference data using $ (if the elements are named), or using [], or [[]]

> mylist <- list(letters=c("A", "b", "c"),   
+ numbers=1:3, matrix(1:25, ncol=5))

## List Structure

> head(mylist)

$letters  
[1] "A" "b" "c"  
  
$numbers  
[1] 1 2 3  
  
[[3]]  
 [,1] [,2] [,3] [,4] [,5]  
[1,] 1 6 11 16 21  
[2,] 2 7 12 17 22  
[3,] 3 8 13 18 23  
[4,] 4 9 14 19 24  
[5,] 5 10 15 20 25

## List referencing

> mylist[1] # returns a list

$letters  
[1] "A" "b" "c"

> mylist["letters"] # returns a list

$letters  
[1] "A" "b" "c"

## List referencing

> mylist[[1]] # returns the vector 'letters'

[1] "A" "b" "c"

> mylist$letters # returns vector

[1] "A" "b" "c"

> mylist[["letters"]] # returns the vector 'letters'

[1] "A" "b" "c"

## List referencing

You can also select multiple lists with the single brackets.

> mylist[1:2] # returns a list

$letters  
[1] "A" "b" "c"  
  
$numbers  
[1] 1 2 3

## List referencing

You can also select down several levels of a list at once

> mylist$letters[1]

[1] "A"

> mylist[[2]][1]

[1] 1

> mylist[[3]][1:2,1:2]

[,1] [,2]  
[1,] 1 6  
[2,] 2 7