
# R Syntax 1: Data Types and Strings

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# AGENDA

01 Handling Different Data Types

02 String Processing

# Basic Instructions

- Getting Help, Using Packages, and Working Directory

## Getting Help

### Accessing the help files

`?mean`
Get help of a particular function.

`help.search('weighted mean')`
Search the help files for a word or phrase.

`help(package = 'dplyr')`
Find help for a package.

### More about an object

`str(iris)`
Get a summary of an object's structure.

`class(iris)`
Find the class an object belongs to.

## Using Packages

`install.packages('dplyr')`
Download and install a package from CRAN.

`library(dplyr)`
Load the package into the session, making all its functions available to use.

`dplyr::select`
Use a particular function from a package.

`data(iris)`
Load a built-in dataset into the environment.

## Working Directory

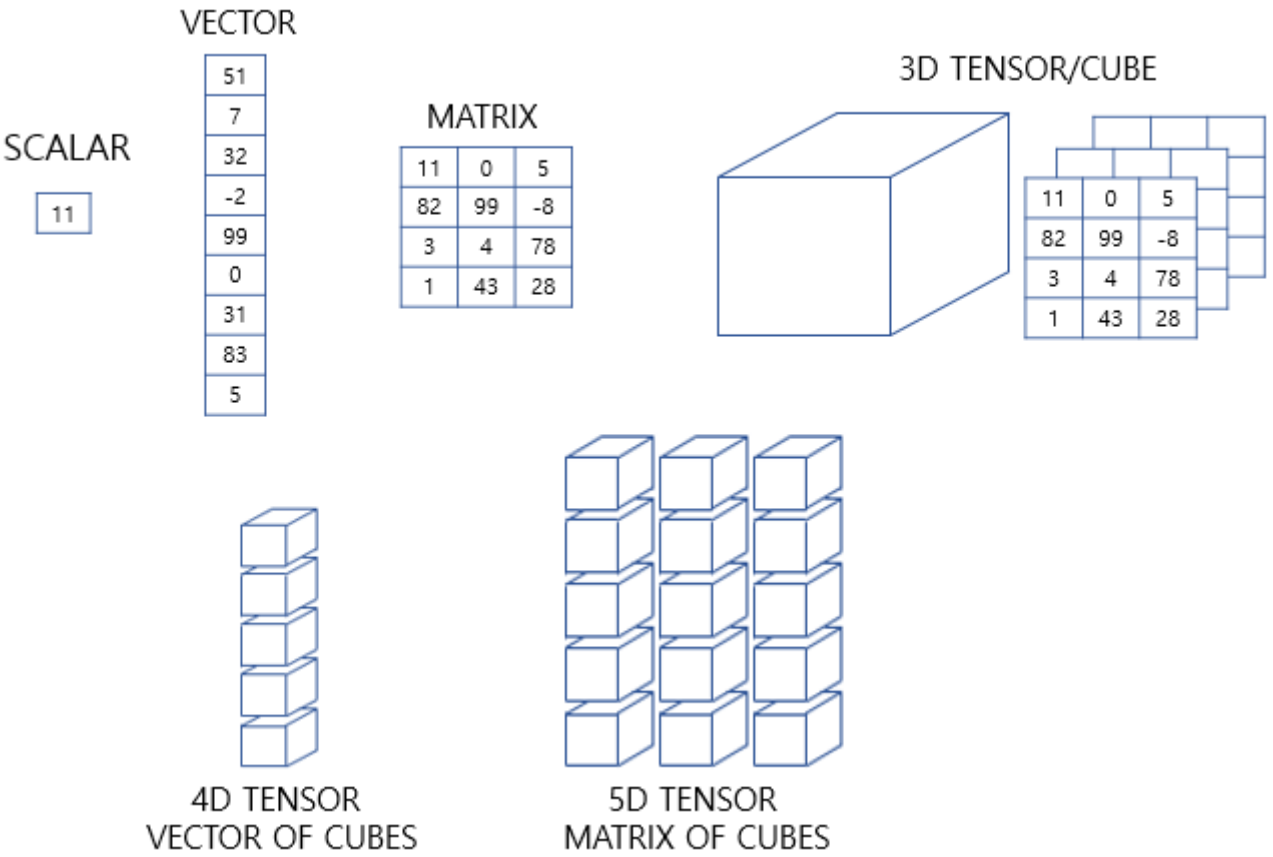
`getwd()`
Find the current working directory (where inputs are found and outputs are sent).

`setwd('C://file/path')`
Change the current working directory.

**Use projects in RStudio to set the working directory to the folder you are working in.**

# Data Types in R

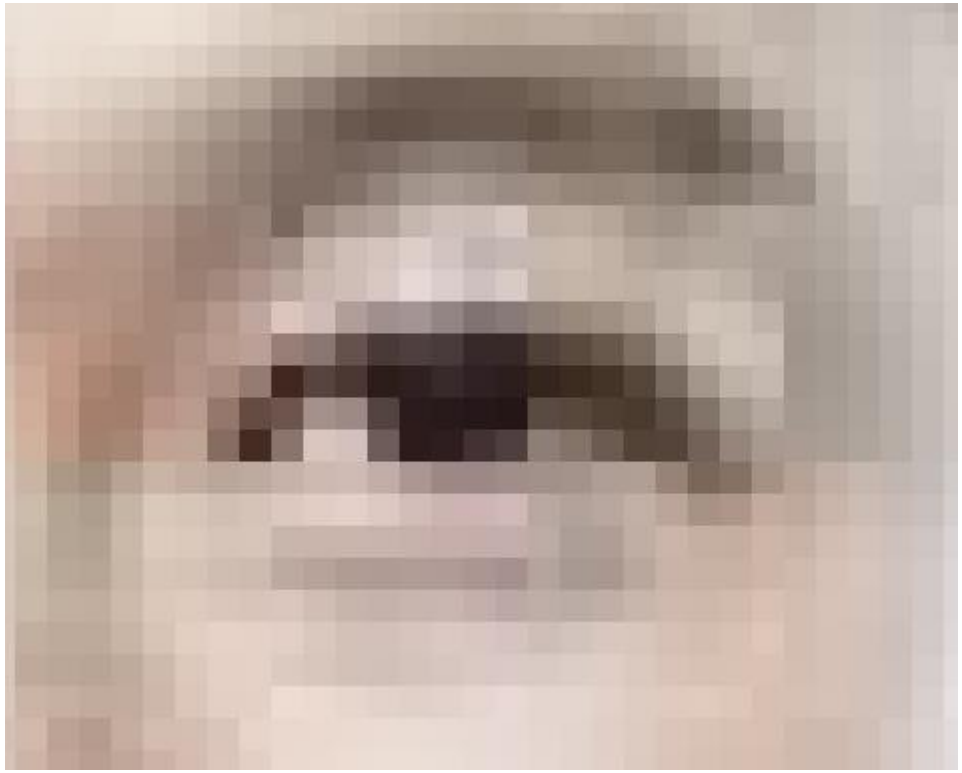
- Data Types w.r.t. dimensions




https://wikidocs.net/37001

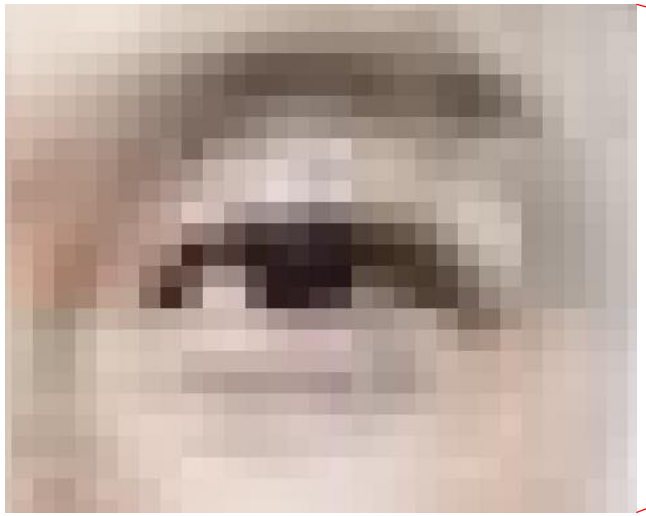
# Data Types in R

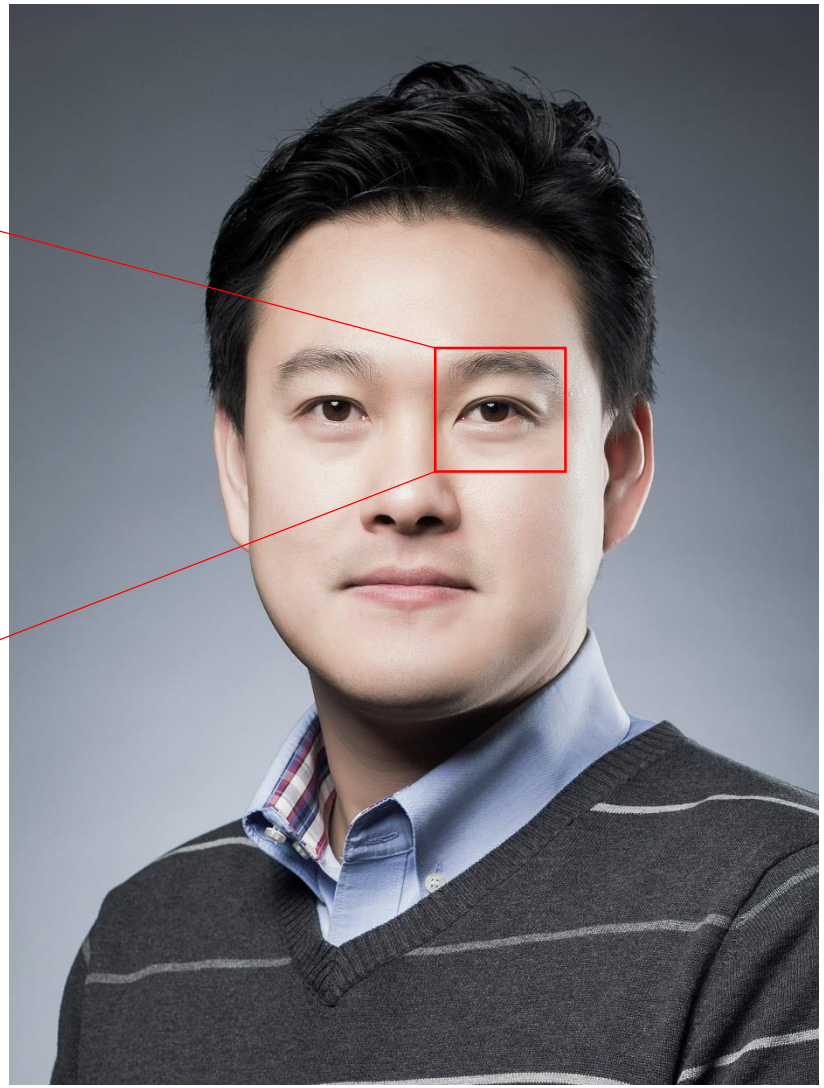
- Tensor in Data Analytics
  - ✓ Whose eye is it?



# Data Types in R

- Tensor in Data Analytics
  - ✓ Whose eye is it?
    - It's my eye





# Data Types in R

- Computers recognize an image as a 3-D Tensor: Width X Height X 3 (RGB)

1,685

2,247

```
> pskang[1:10, 1:10, 1]
          [,1]      [,2]      [,3]      [,4]      [,5]      [,6]      [,7]      [,8]      [,9]     [,10]
 [1,] 0.2784314 0.2784314 0.2745098 0.2745098 0.2745098 0.2745098 0.2705882 0.2705882 0.2862745 0.2901961
 [2,] 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2666667 0.2705882
 [3,] 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2705882 0.2745098
 [4,] 0.2705882 0.2705882 0.2745098 0.2745098 0.2745098 0.2745098 0.2784314 0.2784314 0.2823529 0.2823529
 [5,] 0.2705882 0.2705882 0.2705882 0.2745098 0.2745098 0.2784314 0.2784314 0.2784314 0.2784314 0.2784314
 [6,] 0.2705882 0.2705882 0.2745098 0.2745098 0.2745098 0.2745098 0.2784314 0.2784314 0.2823529 0.2784314
 [7,] 0.2705882 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2784314 0.2941176 0.2862745
 [8,] 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2745098 0.2901961 0.2823529
 [9,] 0.2745098 0.2705882 0.2745098 0.2784314 0.2823529 0.2823529 0.2745098 0.2666667 0.2784314 0.2784314
[10,] 0.2784314 0.2784314 0.2784314 0.2823529 0.2862745 0.2862745 0.2784314 0.2745098 0.2745098 0.2745098
```

```
> pskang[1:10, 1:10, 2]
          [,1]      [,2]      [,3]      [,4]      [,5]      [,6]      [,7]      [,8]      [,9]     [,10]
 [1,] 0.2980392 0.2980392 0.2941176 0.2941176 0.2941176 0.2941176 0.2901961 0.2901961 0.2980392 0.3019608
 [2,] 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2784314 0.2823529
 [3,] 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2823529 0.2862745
 [4,] 0.2901961 0.2901961 0.2941176 0.2941176 0.2941176 0.2941176 0.2980392 0.2980392 0.2941176 0.2941176
 [5,] 0.2901961 0.2901961 0.2901961 0.2941176 0.2941176 0.2980392 0.2980392 0.2980392 0.2901961 0.2901961
 [6,] 0.2901961 0.2901961 0.2941176 0.2941176 0.2941176 0.2941176 0.2980392 0.2980392 0.2941176 0.2901961
 [7,] 0.2901961 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2980392 0.3058824 0.2980392
 [8,] 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.2941176 0.3019608 0.2941176
 [9,] 0.2862745 0.2823529 0.2862745 0.2901961 0.2941176 0.2941176 0.2862745 0.2784314 0.2901961 0.2901961
[10,] 0.2901961 0.2901961 0.2901961 0.2941176 0.2980392 0.2980392 0.2901961 0.2862745 0.2862745 0.2862745
```

```
> pskang[1:10, 1:10, 3]
          [,1]      [,2]      [,3]      [,4]      [,5]      [,6]      [,7]      [,8]      [,9]     [,10]
 [1,] 0.3215686 0.3215686 0.3176471 0.3176471 0.3176471 0.3176471 0.3137255 0.3137255 0.3254902 0.3294118
 [2,] 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3058824 0.3098039
 [3,] 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3098039 0.3137255
 [4,] 0.3137255 0.3137255 0.3176471 0.3176471 0.3176471 0.3176471 0.3215686 0.3215686 0.3215686 0.3215686
 [5,] 0.3137255 0.3137255 0.3137255 0.3176471 0.3176471 0.3215686 0.3215686 0.3215686 0.3176471 0.3176471
 [6,] 0.3137255 0.3137255 0.3176471 0.3176471 0.3176471 0.3176471 0.3215686 0.3215686 0.3215686 0.3176471
 [7,] 0.3137255 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3215686 0.3333333 0.3254902
 [8,] 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3176471 0.3294118 0.3215686
 [9,] 0.3058824 0.3019608 0.3058824 0.3098039 0.3137255 0.3137255 0.3058824 0.2980392 0.3098039 0.3098039
[10,] 0.3098039 0.3098039 0.3098039 0.3137255 0.3176471 0.3176471 0.3098039 0.3058824 0.3058824 0.3058824
```

# Data Types in R

- Variable types
  - ✓ Homogeneous variables
    - All elements are the same type: numeric values in this example

| | Year | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1998 | 0 | 0 | 2 | 21 | 47 | 272 | 391 | 262 | 251 | 178 | 47 | 8 |
| 2 | 1999 | 0 | 4 | 1 | 24 | 145 | 230 | 448 | 195 | 117 | 248 | 17 | 2 |
| 3 | 2000 | 3 | 9 | 0 | 28 | 74 | 281 | 309 | 341 | 190 | 169 | 10 | 8 |
| 4 | 2001 | 1 | 1 | 1 | 64 | 42 | 245 | 271 | 233 | 177 | 127 | 30 | 2 |
| 5 | 2002 | 2 | 12 | 2 | 24 | 87 | 179 | 107 | 173 | 80 | 178 | 18 | 1 |
| 6 | 2003 | 0 | 2 | 18 | 37 | 7 | 182 | 205 | 172 | 72 | 166 | 9 | 1 |
| 7 | 2004 | 2 | 1 | 6 | 54 | 178 | 202 | 201 | 193 | 140 | 97 | 22 | 0 |
| 8 | 2005 | 5 | 2 | 3 | 67 | 57 | 239 | 472 | 295 | 210 | 196 | 35 | 3 |
| 9 | 2006 | 0 | 0 | 26 | 17 | 152 | 270 | 356 | 273 | 168 | 74 | 67 | 0 |
| 10 | 2007 | 0 | 0 | 1 | 36 | 62 | 344 | 371 | 350 | 270 | 118 | 19 | 8 |
| 11 | 2008 | 0 | 15 | 129 | 33 | 61 | 172 | 189 | 262 | 161 | 106 | 37 | 2 |

# Data Types in R

- Variable types
  - ✓ Homogeneous variables
    - Variables (Columns) are different types

| | Name | Number | Position | Age | Height | Weight | College | Salary |
|---|---|---|---|---|---|---|---|---|
| 0 | Avery Bradley | 0.0 | PG | 25.0 | 6-2 | 180.0 | Texas | 7730337.0 |
| 1 | Jae Crowder | 99.0 | SF | 25.0 | 6-6 | 235.0 | Marquette | 6796117.0 |
| 2 | John Holland | 30.0 | SG | 27.0 | 6-5 | 205.0 | Boston University | NaN |
| 3 | R.J. Hunter | 28.0 | SG | 22.0 | 6-5 | 185.0 | Georgia State | 1148640.0 |
| 4 | Jonas Jerebko | 8.0 | PF | 29.0 | 6-10 | 231.0 | NaN | 5000000.0 |
| 5 | Amir Johnson | 90.0 | PF | 29.0 | 6-9 | 240.0 | NaN | 12000000.0 |
| 6 | Jordan Mickey | 55.0 | PF | 21.0 | 6-8 | 235.0 | LSU | 1170960.0 |
| 7 | Kelly Olynyk | 41.0 | C | 25.0 | 7-0 | 238.0 | Gonzaga | 2165160.0 |
| 8 | Terry Rozier | 12.0 | PG | 22.0 | 6-2 | 190.0 | Louisville | 1824360.0 |
| 9 | Marcus Smart | 36.0 | PG | 22.0 | 6-4 | 220.0 | Oklahoma State | 3431040.0 |

# Data Types in R

- Questions
  - ✓ Q1: Are all variables homogeneous?
  - ✓ Q2: Are there more than one record?

| Attribute\No. Records | 1 | >= 2 |
|---|---|---|
| Homogeneous | Vector | Matrix or Array |
| Heterogeneous | List | Dataframe |

- Dataframe makes R powerful to analyze heterogeneous multivariate data

# Data Types in R

| Scalar | **Vector** | List | Matrix | Array | Factor | Data.frame |
|---|---|---|---|---|---|---|

- Vector
  - ✓ Vectors are homogeneous
    - All elements in a vector should be the same mode
  - ✓ Vector has an index for each element
    - A set of indices returns the corresponding sub-vector
    - Index starts from 1 (python: 0)
  - ✓ The elements of a vector can have its own name
  - ✓ Vectors in R is a column-wise vectors

```r
# Part 1-1: Data Handling (Vector) -------------

# Assign values to the vector A & B
A <- c(1,2,3)
B <- c(1, "A", 0.5)

# Check the mode
mode(A)
mode(B)

# Select a subset of vector
A[1]
A[2:3]
A[c(2,3)]

# Assign names
names(A)
names(A) <- c("First", "Second", "Third")

# call by index or name
A[1]
A["First"]
```

# Handling Vectors

- Vector initiation
  - ✓ Do not have to initiate → creation and value assignment are done at the same time
    - a <- 3: create a vector named 'a' and assign the value 3 to it
- Add elements to an existing vector
  - ✓ The size of a vector is fixed when it is created
  - ✓ We have to recreate the vector if we want to add or remove some elements

```
24 # Data Handling: Vector
25 x <- c(1,2,3,4)
26 x
27 x <- c(x[1:3], 10, x[4])
28 x
29 length(x)
```

# Handling Vectors

- Vector reuse
  - ✓ When R conduct an operation with two vectors, the shorter vector is reused to avoid an error

```
> c(1,2,4) + c(10,11,12,13,14)
[1] 11 13 16 14 16
Warning message:
In c(1, 2, 4) + c(10, 11, 12, 13, 14) :
  longer object length is not a multiple of shorter object length
```

  - ✓ Column-first

```
> x <- matrix(1:6, nrow=3, ncol=2)
> x
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
> x + c(1:2)
     [,1] [,2]
[1,]    2    6
[2,]    4    6
[3,]    4    8
```

### Arithmetic Operators

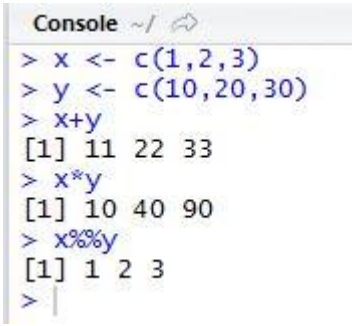
| Operator | Description |
|---|---|
| + | addition |
| - | subtraction |
| * | multiplication |
| / | division |
| ^ or ** | exponentiation |
| x %% y | modulus (x mod y) 5%%2 is 1 |
| x %/% y | integer division 5%/%2 is 2 |

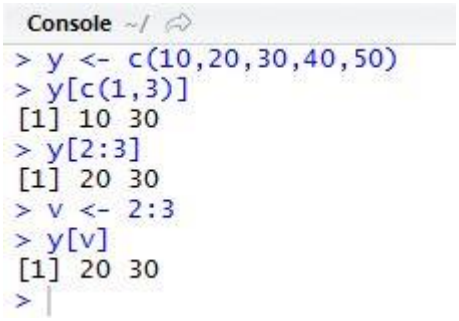
### Logical Operators

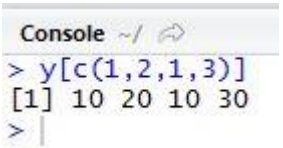
| Operator | Description |
|---|---|
| < | less than |
| <= | less than or equal to |
| > | greater than |
| >= | greater than or equal to |
| == | exactly equal to |
| != | not equal to |
| !x | Not x |
| x \| y | x OR y |
| x & y | x AND y |
| isTRUE(x) | test if X is TRUE |

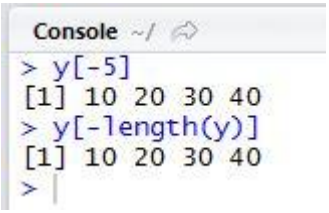
# Handling Vectors

- Vector operations are element-wise
- Vector indexing
  - ✓ Extract a subset of vectors
  - ✓ Index can be used redundantly
  - ✓ A negative index is used to remove the corresponding element



# Handling Vectors

- Creating vectors with operators
  - ✓ : operator: create vectors with certain range
  - ✓ seq: a generalized version of ":" operator
  - ✓ rep: repeat values

Operator Syntax and Precedence

**Description**

Outlines R syntax and gives the precedence of operators.

**Details**

The following unary and binary operators are defined. They are listed in precedence groups, from highest to lowest.

| | |
|---|---|
| `:: :::` | access variables in a namespace |
| `$ @` | component / slot extraction |
| `[ [[` | indexing |
| `^` | exponentiation (right to left) |
| `- +` | unary minus and plus |
| `:` | sequence operator |
| `%any%` | special operators (including `%%` and `%/%`) |
| `* /` | multiply, divide |
| `+ -` | (binary) add, subtract |
| `< > <= >= == !=` | ordering and comparison |
| `!` | negation |
| `& &&` | and |
| `\| \|\|` | or |
| `~` | as in formulae |
| `-> ->>` | rightwards assignment |
| `<- <<-` | assignment (right to left) |
| `=` | assignment (right to left) |
| `?` | help (unary and binary) |

```
Console ~/
> x <- 1:5
> y <- 5:1
> z <- 2
> 1:z-1
[1] 0 1
> 1:(z-1)
[1] 1
>
```

```
Console ~/
> seq(from=12,to=30,by=3)
[1] 12 15 18 21 24 27 30
> seq(from=12,to=30,by=4)
[1] 12 16 20 24 28
> seq(from=1.1,to=2,length=10)
 [1] 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
>
```

```
Console ~/
> rep(10,5)
[1] 10 10 10 10 10
> rep(c(10,20,30),3)
[1] 10 20 30 10 20 30 10 20 30
> rep(1:3,3)
[1] 1 2 3 1 2 3 1 2 3
> rep(c(10,20,30),each=3)
[1] 10 10 10 20 20 20 30 30 30
>
```

# Handling Vectors

- Apply conditions for each element in a vector
  - ✓ any() function: return TRUE if at least one of the elements satisfies the condidition
  - ✓ all() function: return TRUE only when all elements satisfy the condition
- NA vs NULL
  - ✓ NA (Not Available): Some value exists but we cannot exactly know the value
  - ✓ NULL: Physically not exist

```
Console ~/
> x <- 1:10
> x > 8
 [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE  TRUE  TRUE
> any(x > 8)
[1] TRUE
> any(x > 20)
[1] FALSE
> all(x > 8)
[1] FALSE
> all(x > 0)
[1] TRUE
>
```

```
Console ~/
> x <- c(1,2,NA,4,5)
> y <- c(1,2,NULL,4,5)
> mean(x)
[1] NA
> mean(x, na.rm = TRUE)
[1] 3
> mean(y)
[1] 3
>
```

# Handling Vectors

- Filtering: Extract the element that satisfy a given condition
  - ✓ Directly extract from index
  - ✓ subset(): return the values that satisfy the condition
  - ✓ which(): return the indices that satisfy the condition

```
> x <- c(10,20,NA,40,50)
> x[x>20]
[1] NA 40 50
> subset(x, x>20)
[1] 40 50
> which(x>20)
[1] 4 5
```

# Handling List

| Scalar | Vector | List | Matrix | Array | Factor | Data.frame |
|---|---|---|---|---|---|---|

- Lists are heterogeneous
  - ✓ Element in a list can have different modes
  - ✓ List can have other structured object such as dataframe as its element
- Elements in a list are referred by their index
- Elements in a list can have their names

```
91  # Part 1-1: Data Handling (List) -------------
92
93  # Example of a list
94  listA <- list(1, 2, "a")
95  print(listA)
96  listA[[1]]
97  listA[c(1,2)]
98  names(listA)
99  names(listA) <- c("First", "Second", "Third")
100
101 listA[["Third"]]
102 listA$Third
```

# Handling List

- Creating a list
  - ✓ Use list() or vector() function
    - Element names can be assigned using tags

Console ~/

```
> A <- list(name="Kang", salary = 10000, union = TRUE)
> A
$name
[1] "Kang"

$salary
[1] 10000

$union
[1] TRUE

> A$name
[1] "Kang"
>
```

Console ~/

```
> B <- list("Kang", 10000, TRUE)
> B
[[1]]
[1] "Kang"

[[2]]
[1] 10000

[[3]]
[1] TRUE

> B[[1]]
[1] "Kang"
>
```

Console ~/

```
> C <- vector(mode="list")
> C[["name"]] <- "Kang"
> C[["salary"]] <- 10000
> C[["union"]] <- TRUE
> C
$name
[1] "Kang"

$salary
[1] 10000

$union
[1] TRUE
```

# Handling List

- List operations
  - ✓ List indexing
    - Three ways of accessing the elements in a list
    - list$element_name, list[["element_name"]], list[[element's index]]
    - A list is returned if [ ] is used
  - ✓ Add/remove element in a list
    - Add: use a new name
    - Remove: use NULL

```
Console ~/
> C$name
[1] "Kang"
> C[["name"]]
[1] "Kang"
> C[[1]]
[1] "Kang"
>
```

```
Console ~/
> C1 <- C[[1]]
> class(C1)
[1] "character"
> C1
[1] "Kang"
> C2 <- C[1]
> class(C2)
[1] "list"
> C2
$name
[1] "Kang"
```

```
Console ~/
> C$office <- "frontier"
> C
$name
[1] "Kang"

$salary
[1] 10000

$union
[1] TRUE

$office
[1] "frontier"
```

```
Console ~/
> C$salary <- NULL
> C
$name
[1] "Kang"

$union
[1] TRUE

$office
[1] "frontier"
```

# Handling List

- List operations (cont')
  - ✓ Unlist returns a vector with a single mode values

```
Console ~/
> tmplist <- list(a = list(1:5, c("a","b","c")), b = "Z", c = NA)
> tmplist
$a
$a[[1]]
[1] 1 2 3 4 5

$a[[2]]
[1] "a" "b" "c"


$b
[1] "Z"

$c
[1] NA

> unlist(tmplist)
 a1  a2  a3  a4  a5  a6  a7  a8   b   c
"1" "2" "3" "4" "5" "a" "b" "c" "Z"  NA
> unlist(tmplist, use.names = FALSE)
 [1] "1" "2" "3" "4" "5" "a" "b" "c" "Z" NA
>
```

# Handling List

- Applying functions to list
  - ✓ lapply( ) returns a list while sapply( ) returns a vector

```
Console ~/
> A <- list(1:3,25:29)
> A
[[1]]
[1] 1 2 3

[[2]]
[1] 25 26 27 28 29

> lapply(A,median)
[[1]]
[1] 2

[[2]]
[1] 27

> sapply(A,median)
[1]  2 27
>
```

# Handling Matrix and Array

| Scalar | Vector | List | Matrix | Array | Factor | Data.frame |
|---|---|---|---|---|---|---|

- Matrix
  - ✓ Matrix is a vector with dimensions
    - Vectors and lists can be transformed into a matrix
- Array
  - ✓ Matrix can be extended to n-dimensions
    - Indexed by multiple locations and returns subvectors

```
148 # Part 1-3: Data Handling (Matrix)
149
150 # Example of a matrix
151 A <- 1:6
152 dim(A)
153 print(A)
154
155 dim(A) <- c(2,3)
156 print(A)
157
158 B <- list(1,2,3,4,5,6)
159 print(B)
160 dim(B)
161 dim(B) <- c(2,3)
162 print(B)
163
164 D <- 1:12
165 dim(D) <- c(2,3,2)
166 print(D)
```

# Handling Matrix and Array

- Features of matrix in R
  - ✓ Index begins with 1 (0 for python)
  - ✓ Column-major order
- Create a matrix: matrix( )
  - ✓ Method 1: provide all elements and assign the number of columns and rows (column first)
  - ✓ Method 2: provide all elements and assign the number of columns and rows (use row first option)
  - ✓ Method 3: Create an empty matrix and fill each element in

```
Console ~/
> A = matrix(1:15, nrow=5, ncol=3)
> A
     [,1] [,2] [,3]
[1,]    1    6   11
[2,]    2    7   12
[3,]    3    8   13
[4,]    4    9   14
[5,]    5   10   15
>
```

```
Console ~/
> B = matrix(1:15, nrow=5, byrow = T)
> B
     [,1] [,2] [,3]
[1,]    1    2    3
[2,]    4    5    6
[3,]    7    8    9
[4,]   10   11   12
[5,]   13   14   15
>
```

```
Console ~/
> C = matrix(nrow=2,ncol=2)
> C[1,1] = 1
> C[1,2] = 2
> C[2,1] = 3
> C[2,2] = 4
> C
     [,1] [,2]
[1,]    1    2
[2,]    3    4
>
```

# Handling Matrix and Array

- Matrix operations
  - ✓ Linear algebra of matrix: matrix multiplication, matrix-constant multiplication, etc.
  - ✓ Indexing and filtering

```
Console ~/
> A = matrix(1:4, nrow=2, ncol=2)
> B = matrix(seq(from=2,to=8,by=2), nrow=2, ncol=2)
> A
     [,1] [,2]
[1,]    1    3
[2,]    2    4
> B
     [,1] [,2]
[1,]    2    6
[2,]    4    8
> A*B # 행렬 원소간 곱셈
     [,1] [,2]
[1,]    2   18
[2,]    8   32
> A %*% B # 행렬간 곱셈
     [,1] [,2]
[1,]   14   30
[2,]   20   44
> A*3 # 행렬*상수
     [,1] [,2]
[1,]    3    9
[2,]    6   12
> A+B # 행렬간 합
     [,1] [,2]
[1,]    3    9
[2,]    6   12
>
```

```
Console ~/
> C = matrix(1:15, nrow=5, ncol=3)
> C
     [,1] [,2] [,3]
[1,]    1    6   11
[2,]    2    7   12
[3,]    3    8   13
[4,]    4    9   14
[5,]    5   10   15
> C[3,2]
[1] 8
> C[2,]
[1]  2  7 12
> C[,3]
[1] 11 12 13 14 15
> C[2:4,2:3]
     [,1] [,2]
[1,]    7   12
[2,]    8   13
[3,]    9   14
> C[-1,]
     [,1] [,2] [,3]
[1,]    2    7   12
[2,]    3    8   13
[3,]    4    9   14
[4,]    5   10   15
> C[1,] <- c(10, 11, 12)
> C
     [,1] [,2] [,3]
[1,]   10   11   12
[2,]    2    7   12
[3,]    3    8   13
[4,]    4    9   14
[5,]    5   10   15
>
```

# Handling Matrix and Array

- Applying functions to the rows/columns of matrix
  - ✓ Use apply( ) function family: apply( ), sapply( ), tapply( ), lapply( ), etc.
    - apply(m, dimcode, f, fargs)
      - m: matrix
      - dimcode: dimension to apply (1: row, 2: column)
      - f: function
      - fargs: arguments needed to execute f

```
Console ~/
> A <- matrix(c(1:6), nrow=3, ncol=2)
> apply(A,1,mean)
[1] 2.5 3.5 4.5
> apply(A,2,mean)
[1] 2 5
>
```

# Handling Matrix and Array

- Modifying matrix
  - ✓ rbind( ) & cbind( ): combine two matrices
  - ✓ rbind( ): combine two matrices with the same column names (top and bottom)
  - ✓ cbind( ): combine two matrices with the same row names (left and right)

```
Console ~/
> A <- matrix(c(1:6), nrow=3, ncol=2)
> B <- matrix(c(11:16), nrow=3, ncol=2)
> A
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
> B
     [,1] [,2]
[1,]   11   14
[2,]   12   15
[3,]   13   16
>
```

```
Console ~/
> rbind(A,B)
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
[4,]   11   14
[5,]   12   15
[6,]   13   16
> cbind(A,B)
     [,1] [,2] [,3] [,4]
[1,]    1    4   11   14
[2,]    2    5   12   15
[3,]    3    6   13   16
> cbind(A[,1],B[,2])
     [,1] [,2]
[1,]    1   14
[2,]    2   15
[3,]    3   16
>
```

# Handling Matrix and Array

- Assign names for matrix columns/rows
  - ✓ Use colnames( ) and rownames( )

```
Console ~/
> A <- matrix(c(1:6), nrow=3, ncol=2)
> colnames(A)
NULL
> rownames(A)
NULL
> colnames(A) <- c("1st","2nd")
> colnames(A)
[1] "1st" "2nd"
> rownames(A) <- c("First","Second","Third")
> rownames(A)
[1] "First"  "Second" "Third"
> A[,"1st",drop=FALSE]
       1st
First    1
Second   2
Third    3
>
```

# Handling Matrix and Array

- High dimensional array
  - ✓ Use array( ) function

```
Console ~/
> A <- matrix(c(1:15), nrow=5, ncol=3)
> B <- matrix(c(11:25), nrow=5, ncol=3)
> A
     [,1] [,2] [,3]
[1,]    1    6   11
[2,]    2    7   12
[3,]    3    8   13
[4,]    4    9   14
[5,]    5   10   15
> B
     [,1] [,2] [,3]
[1,]   11   16   21
[2,]   12   17   22
[3,]   13   18   23
[4,]   14   19   24
[5,]   15   20   25
> C <- array(data=c(A,B),dim=c(3,2,2))
> C
, , 1

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

, , 2

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

# Handling Factor



- Factor
  - ✓ Vector representation for nominal/categorical variables
    - Factor has its levels that are equivalent the number of possible values
- Usage
  - ✓ Categorical variable representation: 1 level for 1 category
  - ✓ Grouping and tagging
- Factor levels must be consistent!

```
245 # Part 1-4: Data Handling (Factor)
246
247 # Example of a factor
248 A <- c("Cho","Kim","Kang")
249 B <- as.factor(A)
250
251 print(A)
252 print(B)
253
254 mode(A)
255 mode(B)
256
257 A[1]+A[2]
258 B[1]+B[2]
```

```
> A[1]+A[2]
Error in A[1] + A[2] : non-numeric argument to binary operator
> B[1]+B[2]
[1] NA
Warning message:
In Ops.factor(B[1], B[2]) :
  요인(factors)에 대하여 의미있는 '+'가 아닙니다.
```

# Handling Factor

- Factor
  - ✓ Factor in R is a vector with additional information
    - Additional information is a set of non-redundant values called level
    - The length of a factor is the number of elements, not levels
    - Possible to add a new level
    - A new value with non-existing level is considered as NA

```
Console ~/
> x <- c(5,12,13,12)
> xf <- factor(x)
> xf
[1] 5  12 13 12
Levels: 5 12 13
> str(xf)
 Factor w/ 3 levels "5","12","13": 1 2 3 2
> unclass(xf)
[1] 1 2 3 2
attr(,"levels")
[1] "5"  "12" "13"
> length(xf)
[1] 4
>
```

```
Console ~/
> xff <- factor(x, levels=c(5,12,13,88))
> xff
[1] 5  12 13 12
Levels: 5 12 13 88
> xff[2] <- 88
> xff
[1] 5  88 13 12
Levels: 5 12 13 88
> xff[2] <- 20
Warning message:
In `[<-.factor`(`*tmp*`, 2, value = 20) :
  invalid factor level, NA generated
> xff
[1] 5    <NA> 13   12
Levels: 5 12 13 88
>
```

# Handling Factor

- Applying function to a factor
  - ✓ tapply( )
    - Useful to make frequency table with different categories
    - Can be used to more than two factors

```
Console ~/
> ages <- c(25,26,55,37,21,42)
> affils <- c("R","D","D","R","U","D")
> tapply(ages, affils, mean)
 D  R  U
41 31 21
>
```

```
Console ~/
> gender <- c("M", "M", "F", "M", "F", "F")
> age <- c(47,59,21,32,33,24)
> income <- c(55000,88000,32450,76500,123000,45650)
> tmp <- data.frame(gender, age, income)
> tmp$over25 <- ifelse(tmp$age>25,1,0)
> tmp
  gender age income over25
1      M  47  55000      1
2      M  59  88000      1
3      F  21  32450      0
4      M  32  76500      1
5      F  33 123000      1
6      F  24  45650      0
> tapply(tmp$income, list(tmp$gender, tmp$over25), mean)
      0         1
F 39050 123000.00
M    NA  73166.67
>
```

# Handling Factor

- Applying function to a factor
  - ✓ split( ) function
    - Used to make groups
    - can be used to more than two factors

```
Console ~/
> split(tmp$income, list(tmp$gender, tmp$over25))
$F.0
[1] 32450 45650

$M.0
numeric(0)

$F.1
[1] 123000

$M.1
[1] 55000 88000 76500
```

# Handling Dataframe



- Dataframe
  - ✓ A table with rows and columns
  - ✓ Regarded as a special case of list
  - ✓ Can have different modes for different columns
  - ✓ Elements in a column must have the same modes
  - ✓ Columns can have names

```
296 # Part 1-5: Data Handling (DataFrame) ------
297
298 # Example of data frame
299 A <- c(1,2,3)
300 B <- c("a","b","c")
301 C <- data.frame(A,B)
302 C
303 C[[1]]
304 C[[2]]
305 C[1,2]
306 C$B[2]
307
308 C <- data.frame(A,B, stringsAsFactors=FALSE)
309 C
310 C[[1]]
311 C[[2]]
312 C[1,2]
313 C$B[2]
```

# Handling Dataframe

- Creating and accessing Dataframe
  - ✓ Use data.frame( ) function to create a dataframe
  - ✓ Three ways to access a certain element

```
Console ~/
> kids <- c("Jack", "Jill")
> ages <- c(12,10)
> d <- data.frame(kids, ages, stringsAsFactors=FALSE)
> d
  kids ages
1 Jack   12
2 Jill   10
>
```

```
Console ~/
> d[[1]]
[1] "Jack" "Jill"
> class(d[[1]])
[1] "character"
> d$kids
[1] "Jack" "Jill"
> class(d$kids)
[1] "character"
> d[,1]
[1] "Jack" "Jill"
> class(d[,1])
[1] "character"
> d[1]
  kids
1 Jack
2 Jill
> class(d[1])
[1] "data.frame"
>
```

# Handling Dataframe

- Extracting and filtering a subset of dataframe
  - ✓ Same as matrix
- Combine dataframe
  - ✓ Same as matrix

```
Console ~/
> Exam
  Exam1 Exam2 Quiz
1   2.0   3.3  4.0
2   3.3   2.0  3.7
3   4.0   4.0  4.0
4   2.3   0.0  3.3
5   2.3   1.0  3.3
6   3.3   3.7  4.0
> Exam[2:5,]
  Exam1 Exam2 Quiz
2   3.3     2  3.7
3   4.0     4  4.0
4   2.3     0  3.3
5   2.3     1  3.3
> Exam[2:5,2]
[1] 2 4 0 1
> Exam[2:5,2, drop=FALSE]
  Exam2
2     2
3     4
4     0
5     1
>
```

```
Console ~/
> Exam[Exam$Exam1 > 3,]
  Exam1 Exam2 Quiz
2   3.3   2.0  3.7
3   4.0   4.0  4.0
6   3.3   3.7  4.0
> rbind(d,list("Laura",19))
   kids ages
1  Jack   12
2  Jill   10
3 Laura   19
>
```

# Handling Dataframe

- Merge dataframes
  - ✓ If there are more than on sources of data tables in a database
  - ✓ Inner/outer/left/right joins are possible

```
> merge(dfA, dfB) # default: inner join
   kids ages state
1  Jill   10    NY
2 Laura   19    CA
> merge(dfA, dfB, all = TRUE) # outer join
   kids ages state
1 Alice   NA    MA
2  Jack   12  <NA>
3  Jill   10    NY
4 Laura   19    CA
> merge(dfA, dfB, all.x = TRUE) # left join
   kids ages state
1  Jack   12  <NA>
2  Jill   10    NY
3 Laura   19    CA
> merge(dfA, dfB, all.y = TRUE) # right join
   kids ages state
1 Alice   NA    MA
2  Jill   10    NY
3 Laura   19    CA
```

# Handling Dataframe

- Merge dataframes
  - ✓ If different data frames have different column name strategy, explicitly state the column names to use

```
firstname <- c("Alice","Jill", "Laura")
state <- c("MA", "NY", "CA")
dfC <- data.frame(firstname, state, stringsAsFactors=FALSE)
dfC

merge(dfA, dfC, by.x="kids", by.y="firstname")
```

```
> dfC <- data.frame(firstname, state, stringsAsFactors=FALSE)
> dfC
  firstname state
1     Alice    MA
2      Jill    NY
3     Laura    CA
> merge(dfA, dfC, by.x="kids", by.y="firstname")
   kids ages state
1  Jill   10    NY
2 Laura   19    CA
```

# AGENDA

01 Handling Different Data Types

02 String Processing

# String Processing

- The length of a string
  - ✓ Use nchar( ) function instead of length( )
    - Space and special characters can be counted as well
- Concatenate strings
  - ✓ Use paste( ) function
    - Various spacing strategies can be used
    - Non-character values are also possible

```
Console ~/
> S <- "Welcome to Data Science!"
> length(S)
[1] 1
> nchar(S)
[1] 24
> S1 <- "My name is"
> S2 <- "Pilsung Kang"
> paste(S1, S2)
[1] "My name is Pilsung Kang"
> paste(S1, S2, sep="-")
[1] "My name is-Pilsung Kang"
> paste(S1, S2, sep="")
[1] "My name isPilsung Kang"
>
```

```
Console ~/
> paste("The value of log10 is", log(10))
[1] "The value of log10 is 2.30258509299405"
> S1 <- c("My name is", "Your name is")
> S2 <- c("Pilsung")
> S3 <- c("Pilsung", "Younho", "Hakyeon")
> paste(S1,S2)
[1] "My name is Pilsung"   "Your name is Pilsung"
> paste(S1,S3)
[1] "My name is Pilsung"  "Your name is Younho" "My name is Hakyeon"
> stooges <- c("Dongmin", "Sangkyum", "Junhong")
> paste(stooges, "loves", "R.")
[1] "Dongmin loves R."  "Sangkyum loves R." "Junhong loves R."
> paste(stooges, "loves", "R", collapse = ", and ")
[1] "Dongmin loves R, and Sangkyum loves R, and Junhong loves R"
>
```

# String Processing

- Extract sub-strings
  - ✓ Use substring(string, start, end) function
    - Extract the substring that begins with "start" and ends with "end"
    - If the string argument is a vector, the other options are applied to all elements

```
Console ~/
> substr("Data Science", 1, 4)
[1] "Data"
> substr("Data Science", 6, 10)
[1] "Scien"
> stooges <- c("Dongmin", "Sangkyum", "Junhong")
> substr(stooges, 1,3)
[1] "Don" "San" "Jun"
> cities <- c("New York, NY", "Los Angeles, CA", "Peoria, IL")
> substr(cities, nchar(cities)-1, nchar(cities))
[1] "NY" "CA" "IL"
>
```

# String Processing

- Split text
  - ✓ Use strsplit(string, separator) function
    - A simple string or regular expression can be used as a separator
    - Ex: split the file path using "/" as a separator

```
Console ~/
> path <- "C:/home/mike/data/trials.csv"
> strsplit(path,"/")
[[1]]
[1] "C:"          "home"       "mike"       "data"       "trials.csv"
```

```
Console ~/
> path <- c("C:/home/mike/data/trials.csv",
+ "C:/home/mike/data/errors.txt",
+ "C:/home/mike/data/report.doc")
> strsplit(path,"/")
[[1]]
[1] "C:"          "home"       "mike"       "data"       "trials.csv"

[[2]]
[1] "C:"          "home"       "mike"       "data"       "errors.txt"

[[3]]
[1] "C:"          "home"       "mike"       "data"       "report.doc"
```

# String Processing

- Regular expression
  - ✓ a sequence of characters that define a search pattern
  - ✓ this pattern is then used by string searching algorithms

```
Console ~/
> strsplit(path, "om")
[[1]]
[1] "C:/h"                    "e/mike/data/trials1.csv"

[[2]]
[1] "C:/h"                    "e/mike/data/errors2.txt"

[[3]]
[1] "C:/h"                    "e/mike/data/report3.doc"

> strsplit(path, "[hm]")
[[1]]
[1] "C:/"                "o"                   "e/"                  "ike/data/trials1.csv"

[[2]]
[1] "C:/"                "o"                   "e/"                  "ike/data/errors2.txt"

[[3]]
[1] "C:/"                "o"                   "e/"                  "ike/data/report3.doc"

> strsplit(path, "i.e")
[[1]]
[1] "C:/home/m"          "/data/trials1.csv"

[[2]]
[1] "C:/home/m"          "/data/errors2.txt"

[[3]]
[1] "C:/home/m"          "/data/report3.doc"
```

```
Console ~/
> strsplit(path, "\\.")
[[1]]
[1] "C:/home/mike/data/trials1" "csv"

[[2]]
[1] "C:/home/mike/data/errors2" "txt"

[[3]]
[1] "C:/home/mike/data/report3" "doc"

> strsplit(path, "r{2}")
[[1]]
[1] "C:/home/mike/data/trials1.csv"

[[2]]
[1] "C:/home/mike/data/e" "ors2.txt"

[[3]]
[1] "C:/home/mike/data/report3.doc"

> strsplit(path, "[[:digit:]]")
[[1]]
[1] "C:/home/mike/data/trials" ".csv"

[[2]]
[1] "C:/home/mike/data/errors" ".txt"

[[3]]
[1] "C:/home/mike/data/report" ".doc"
```

Regular expression in R

# String Processing

- Regular expression

| POSIX | 비표준 | 펄/Tcl | Vim | ASCII | 설명 |
|---|---|---|---|---|---|
| [:alnum:] | | | | [A-Za-z0-9] | 영숫자 |
| | [:word:] | ₩w | ₩w | [A-Za-z0-9_] | 영숫자 + "_" |
| | | ₩W | ₩W | [^A-Za-z0-9_] | 낱말이 아닌 문자 |
| [:alpha:] | | | ₩a | [A-Za-z] | 알파벳 문자 |
| [:blank:] | | | ₩s | [ ₩t] | 공백과 탭 |
| | | ₩b | ₩< ₩> | (?<=₩W)(?=₩w)\|(?<=₩w)(?=₩W) | 낱말 경계 |
| [:cntrl:] | | | | [₩x00-₩x1F₩x7F] | 제어 문자 |
| [:digit:] | | ₩d | ₩d | [0-9] | 숫자 |
| | | ₩D | ₩D | [^0-9] | 숫자가 아닌 문자 |
| [:graph:] | | | | [₩x21-₩x7E] | 보이는 문자 |
| [:lower:] | | | ₩l | [a-z] | 소문자 |
| [:print:] | | | ₩p | [₩x20-₩x7E] | 보이는 문자 및 공백 문자 |
| [:punct:] | | | | [][!"#$%&'()*+,./:;<=>?@₩^_`{\|}~-] | 구두점 |
| [:space:] | | ₩s | ₩_s (단순히 줄 끝에 추가) | [ ₩t₩r₩n₩v₩f] | 공백 문자 |
| | | ₩S | | [^ ₩t₩r₩n₩v₩f] | 공백이 아닌 모든 문자 |
| [:upper:] | | | ₩u | [A-Z] | 대문자 |
| [:xdigit:] | | | ₩x | [A-Fa-f0-9] | 16진수 |

From: wikipedia

# String Processing

- Substitution
  - ✓ Use sub(old, new, string) or gsub(old, new, string) functions
  - ✓ sub( ) replaces the first substring whereas gsub( ) replaces all substrings

```
Console ~/
> tmpstring <- "Kim is stupid and Kang is stupid too"
> sub("stupid", "smart", tmpstring)
[1] "Kim is smart and Kang is stupid too"
> gsub("stupid", "smart", tmpstring)
[1] "Kim is smart and Kang is smart too"
```

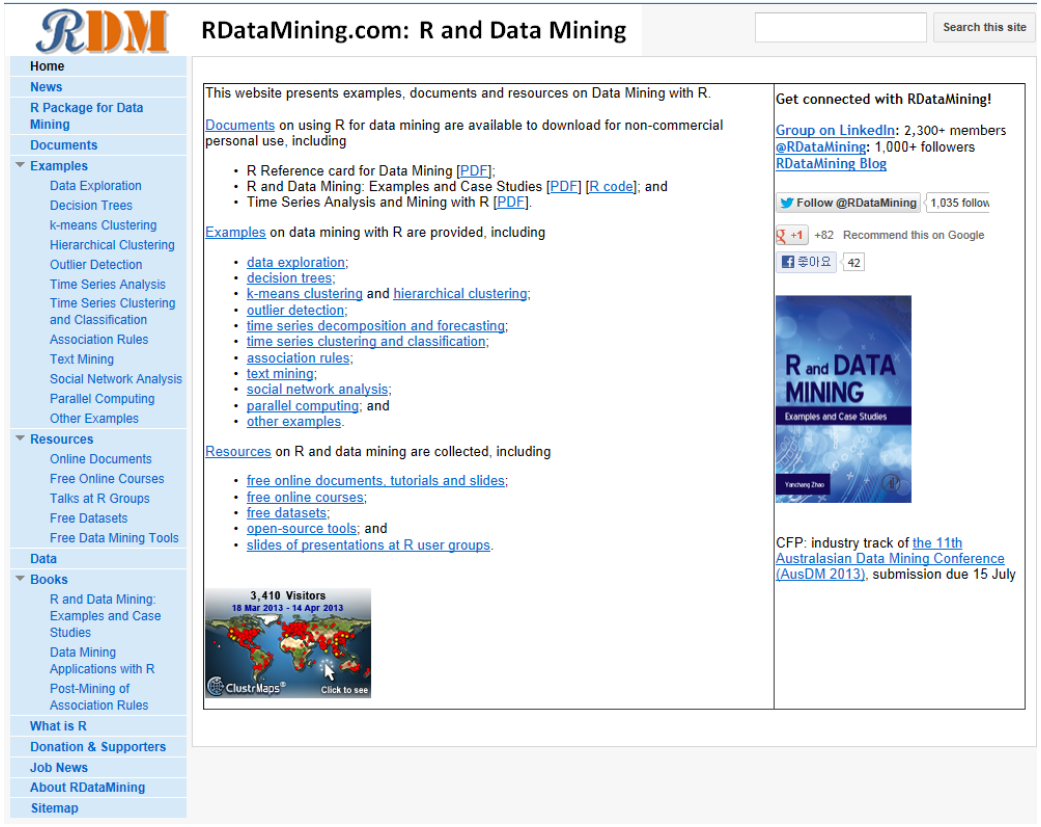
- String pattern matching
  - ✓ Use grep(pattern, x) function
    - Return the index that matches pattern

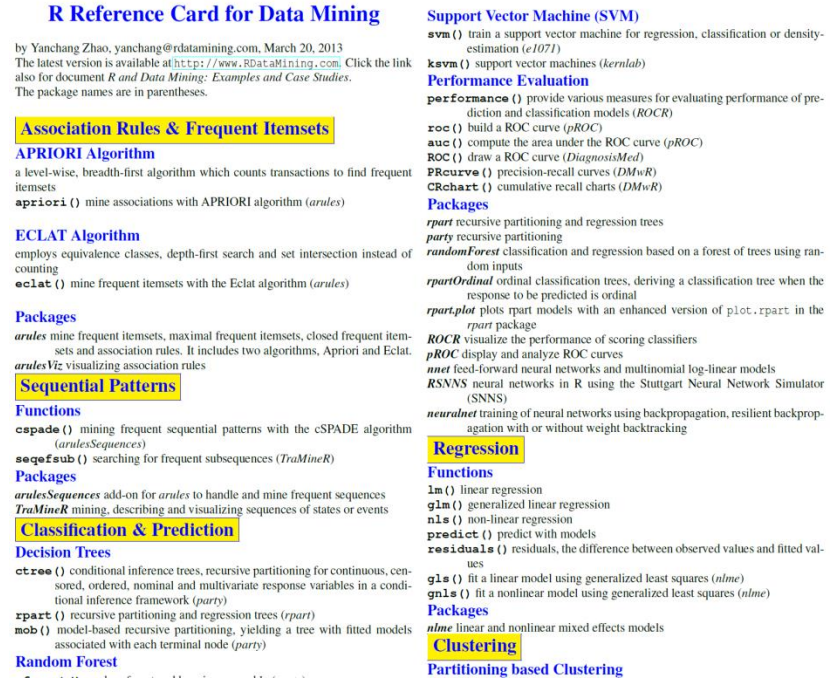
```
Console ~/
> grep("mike",path)
[1] 1 2 3
> grep("errors",path)
[1] 2
```


ANY
questions?

# References

- R Datamining
  - ✓ http://www.rdatamining.com



# References

- R Bloggers
  - ✓ http://r-bloggers.com