R PROGRAMMING WORKSHOP (BASICS) FOR RESEARCHERS

Lesson 1

Prepared by **PolyU IT Support for Research**, Aug 2020

COURSE INFO

DATE: 18 (TUE) , 21 (FRI) & 25 (TUE) AUG (3 SESSIONS)

TIME: 14:30-16:30

PLATFORM FOR HOSTING WORKSHOPS: MS TEAMS

GIT REPO URL:

https://polyu.hk/dAvpL

WHO AM I?

ALEX LAM

- SENIOR SPECIALIST
- INFORMATION AND TECHNOLOGY SERVICE
- HAS EXTENSIVE PROGRAMMING EXPERIENCE ACROSS C, PYTHON, PHP, JS AND R

CONTACT PERSON

Tommy Ng

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- Location: Room S1409, 14/F, South Tower, PolyU West Kowloon Campus
- tommy.ng@speed-polyu.edu.hk

REQUIREMENT

- RESEARCHER ORIENTED
- BASIC UNDERSTANDING OF ANY OF THE PROGRAMMING LANGUAGES

WHAT YOU WILL LEARN

COURSE OUTLINE

- INTRODUCTION TO R
- IDE TOOLS FOR R WITH ANACONDA
- MODULES & PACKAGES
- VARIABLES & TYPES
- BASIC OPERATORS
- BASIC STRING OPERATIONS
- DATA STRUCTURE
- CONDITIONS
- LOOPS
- FUNCTIONS
- DATA PROCESSING WITH DATAFRAME
- BASICDATA VISUALIZATION WITH GGPLOT
- BASIC STATISTICS WITH R

WHAT IS R & WHY R?

- R IS A PROGRAMMING LANGUAGE AND SOFTWARE ENVIRONMENT
- GOOD AT STATISTICAL ANALYSIS, GRAPHICS REPRESENTATION AND REPORTING.
- CREATED BY ROSS IHAKA AND ROBERT GENTLEMAN AT THE UNIVERSITY OF AUCKLAND
- FREELY AVAILABLE UNDER THE GNU GENERAL PUBLIC LICENSE
- NO COMPILATION NEEDED
- ENABLE FAST PROTOTYPE

R VS PYTHON

	R	Python
Usage	Statistical modeling, data analysis	Web development, Data analysis, scientific calculation
Users	Statisticians and data scientist. Common in R&D institutes	Software engineers and data scientist Widely used in varies industries.
Visualization	ggplot2	Matplotlib

REFERENCES

- HANDS ON PROGRAMMING WITH R (https://rstudio-education.github.io/hopr/index.html)
- R FOR DATA SCIENCE (HTTPS://R4DS.HAD.CO.NZ/)
- TUTORIALPOINT HAS GOOD QUICK REFERENCES (HTTPS://WWW.TUTORIALSPOINT.COM/R/INDEX.HTM)
- UDACITY "DATA AND VISUAL ANALYTICS (HTTPS://CLASSROOM.UDACITY.COM/COURSES/UD404)

REFERENCES

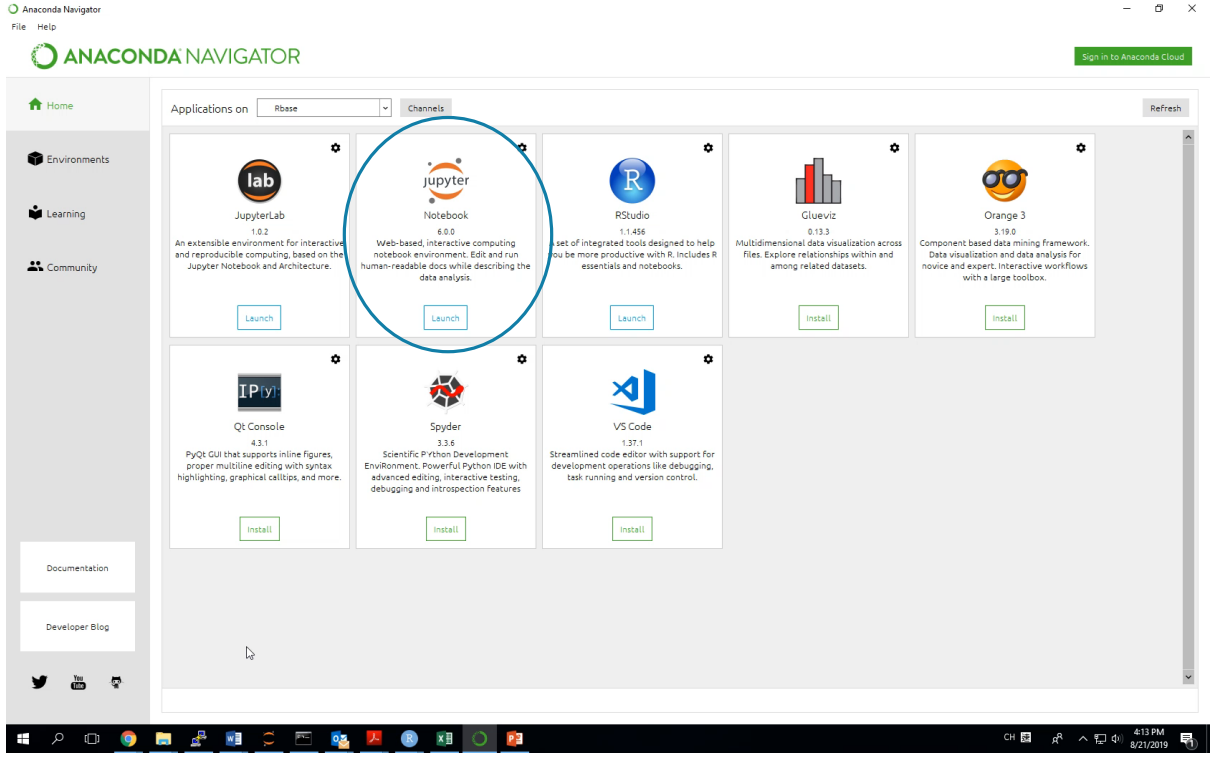
- INSTALLATION OF ANACONDA WITH RSTUDIO (HTTPS://DOCS.ANACONDA.COM/ANACONDA/NAVIGATOR/TUTORIALS/CREATE-R-ENVIRONMENT/)
- ONLY RSTUDIO (HTTPS://RSTUDIO.COM/PRODUCTS/RSTUDIO/DOWNLOAD/)

INTRODUCTION TO R IDE PLATFORMS

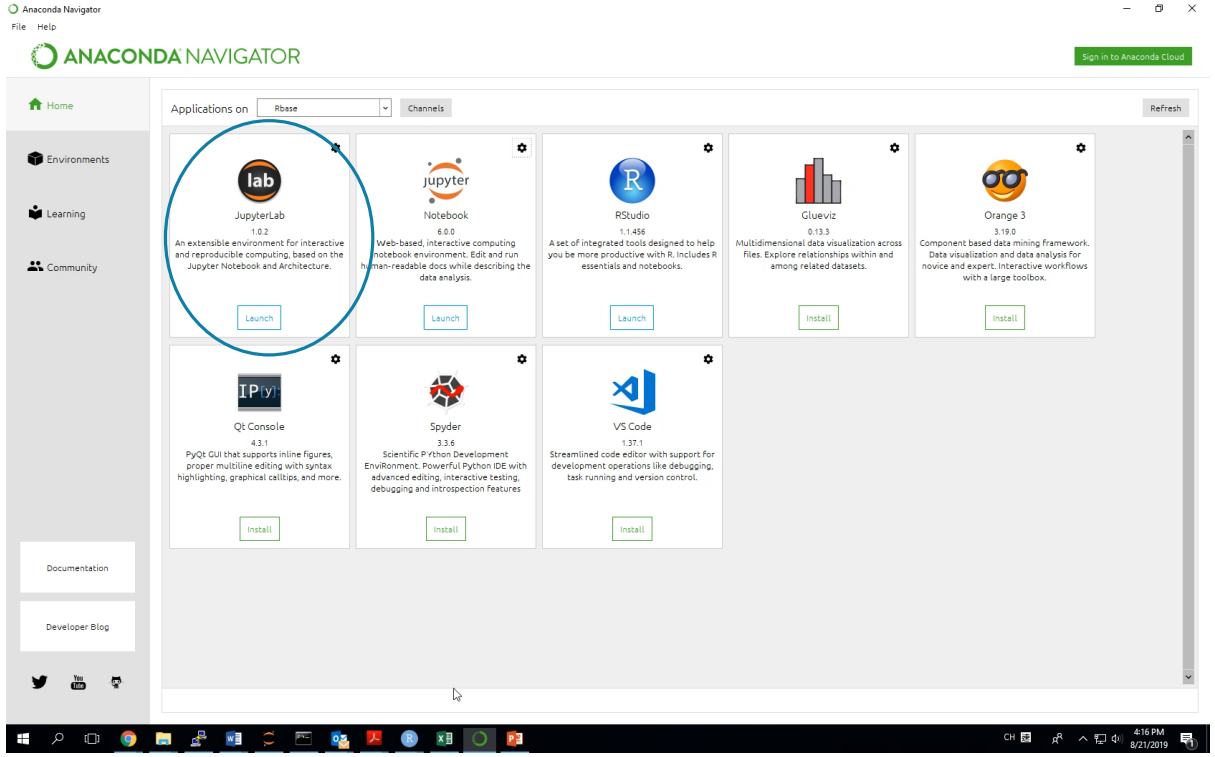
- ANACONDA IS A FREE AND OPEN-SOURCE DISTRIBUTION OF THE PYTHON AND R PROGRAMMING LANGUAGES FOR SCIENTIFIC COMPUTING
- AIMS TO SIMPLIFY PACKAGE MANAGEMENT AND DEPLOYMENT
- ANACONDA
  - *R STUDIO*
  - *JUPYTER NOTEBOOK*
  - *JUPYTER LAB*
- FOCUS ON RSTUDIO IN THIS COURSE

ANACONDA

JUPYTER NOTEBOOK



JUPYTER LAB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Rbase
Channels
Refresh
JupyterLab
1.0.2
An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.
Launch
Notebook
6.0.0
Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.
Launch
RStudio
1.1.456
A set of integrated tools designed to help you be more productive with R. Includes R essentials and notebooks.
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Glueviz
0.13.3
Multidimensional data visualization across files. Explore relationships within and among related datasets.
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3.19.0
Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows with a large toolbox.
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Qt Console
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PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.
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3.3.6
Scientific PYthon Development EnviRonment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features
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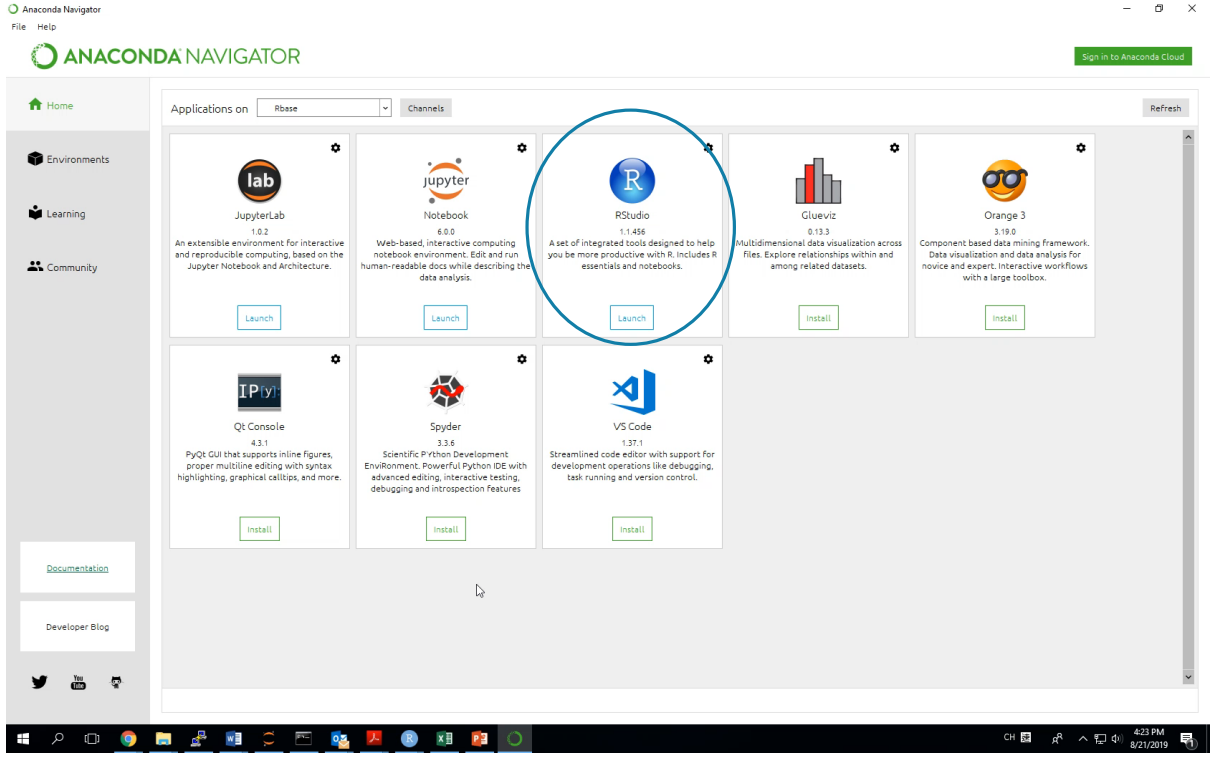
VS Code
1.37.1
Streamlined code editor with support for development operations like debugging, task running and version control.
Install
4:16 PM
8/21/2019

RSTUDIO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JupyterLab
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An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.
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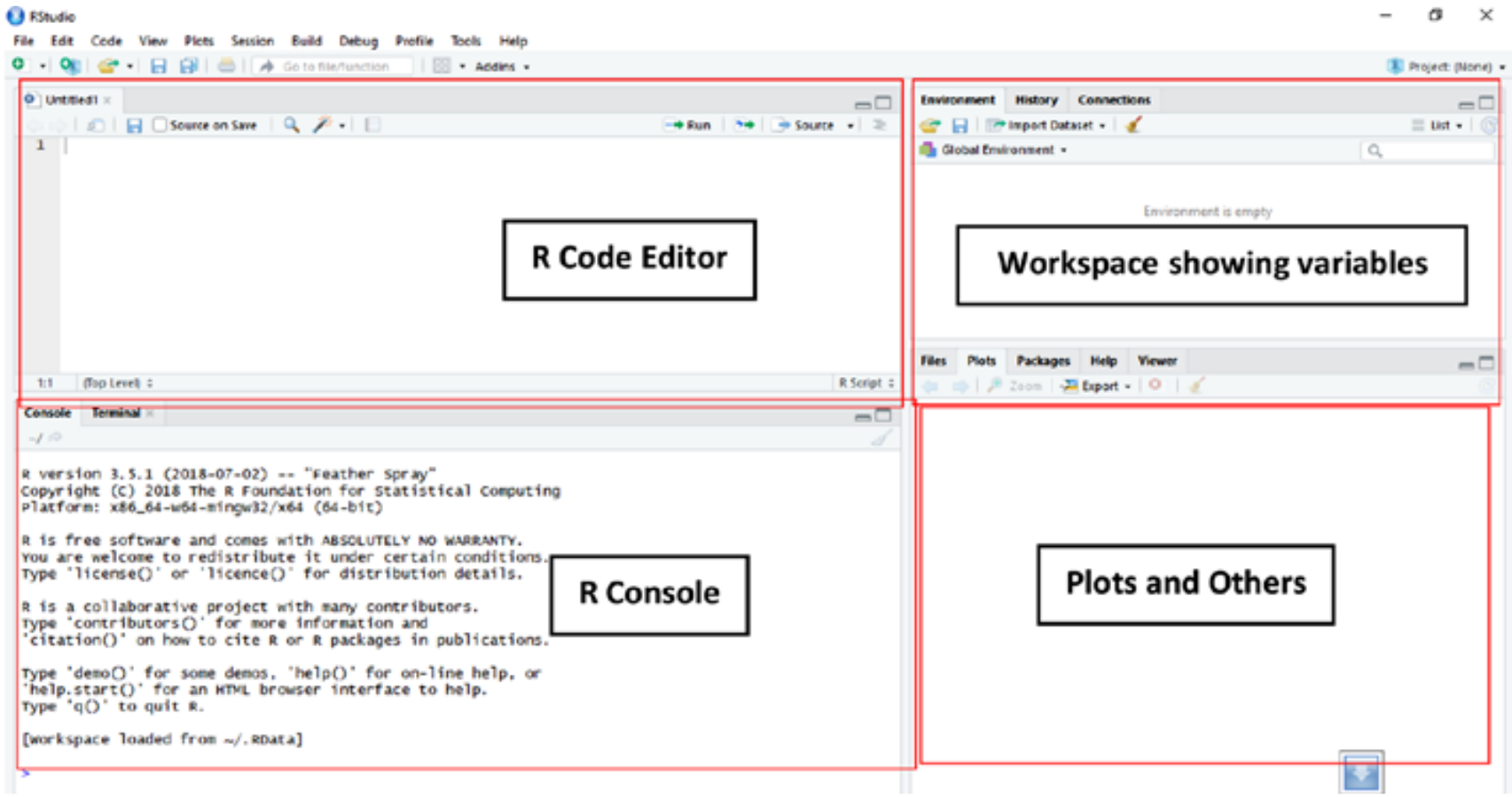
RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Untitled1
Source on Save
Run
Source
R Code Editor
Environment History Connections
Import Dataset
Global Environment
Environment is empty
Workspace showing variables
Files Plots Packages Help Viewer
Console Terminal
R version 3.5.1 (2018-07-02) -- "Feather Spray"
Copyright (C) 2018 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
[Workspace loaded from ~/.RData]
R Console
Plots and Others

HELP DOCUMENT OF R

- HELP(THE COMMAND TO BE CHECKED)
- FOR EXAMPLE:

  - *HELP(PLOT)*

  - *HELP(LIST)*

- EXERCISE:

  - *TRY TO LOAD THE DOCUMENT OF EACH OF THE FOLLOWING COMMAND:*

  - *AS*

  - *IS*

  - *MATRIX*

COMMAND FOR WORKSPACE

- LS()

  - LIST VARIABLE(S) IN WORKSPACE MEMORY

- SAVE.IMAGE(FILE="TEST")

  - SAVE THE WHOLE WORKSPACE TO A FILE

- SAVE(A,FILE="TESTA")

  - SAVE SPECIFIC VARIABLE(S) TO A FILE

- LOAD("TEST")

  - LOAD WORKSPACE VARIABLE(S) FROM A FILE

- GETWD()

  - GET CURRENT DIRECTORY

- SETWD(DIR)

  - SET WORKING DIRECTORY

MODULE AND PACKAGES

- INSTALL.PACKAGES("GGPLOT2")
- LIBRARY("GGPLOT2")

VARIABLE & R-OBJECT

- IN R, THE VARIABLES ARE NOT DECLARED AS SOME DATA TYPE AS C,JAVA ETC
- VARIABLES ARE ASSIGNED WITH R-OBJECTS.
- DATA TYPES OF THE R-OBJECT BECOMES THE DATA TYPE OF THE VARIABLE
- R-OBJECTS ARE BUILT UPON THE ATOMIC VECTORS.
- “ATOMIC VECTORS” HAS SINGLE VALUE

VARIABLE AND ASSIGNMENT

- DECLARE VARIABLE

  - A<-5

  - B<-"POLYU"

- FOR VARIABLE WITH MULTIPLE VALUES, USE C() TO COMBINE VALUES INTO VECTOR

  - V<-C(1,2,3,4)

  - G<-C('A','B','C','D')

- ALL VALUE SHOULD BE IN THE SAME TYPE

- FOR VARIABLE WITH MULTIPLE VALUES AND DIFFERENT TYPES, USE C() TO DECLARE VECTOR AS A INPUT TO LIST()

  - LIST1 <- LIST(C(18,4,6),'POLYU','HK',TRUE)

- WILL EXPLAIN DATA TYPES AND DATA STRUCTURE FOR NEXT COUPLE OF SLIDES

- <- , = AND -> CAN BE USED, BUT <- IS RECOMMENDED

DATA TYPE

The variables are assigned with R-Objects and the data type of the R-object becomes the data type of the variable

DATA TYPE	EXAMPLE	Code	Result
Logical	TRUE, FALSE	v <- FALSE print(class(v))	?
Numeric	1.3,4.1,50,666.1	v <- 666.1 print(class(v))	?
Integer	5L, 88L,1091L	v <- 2L print(class(v))	?
Complex	4+5i	v <- 2+5i print(class(v))	?
Character	'a' , "good", "TRUE", '23.4'	v <- "TRUE" print(class(v))	?
Raw	"Hello" is stored as 48 65 6c 6c 6f	v <-charToRaw("Hello") print(class(v))	?

DATA TYPE

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Logical	TRUE, FALSE	v <- FALSE print(class(v))	
Numeric	1.3,4.1,50,666.1	v <- 666.1 print(class(v))	
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Raw	"Hello" is stored as 48 65 6c 6c 6f	v <- charToRaw("Hello") print(class(v))	

DON’T DO THIS

- D<-’1’
- E<-999
- D+E
- WHAT WOULD YOU GET?
- HOW TO SOLVE IT?

CONVERTING DATA TYPE

F <- AS.NUMERIC(D)

F + E

- AS.INTEGER
- AS.LOGICAL
- AS.CHARACTER
- AS.RAW
- SEE THE DOCUMENTATION WHEN YOU NEED THEM

BASIC STRING

- BEGINNING AND END OF A STRING SHOULD BE BOTH DOUBLE QUOTES OR BOTH SINGLE QUOTE
- DOUBLE QUOTES CAN BE INSERTED INTO A STRING STARTING AND ENDING WITH SINGLE QUOTE
- SINGLE QUOTE CAN BE INSERTED INTO A STRING STARTING AND ENDING WITH DOUBLE QUOTES
- PASTE(…)- FOR CONNECTING STRINGS
- FORMAT(..)- FOR FORMATTING STRINGS
- NCHAR(X)- USED FOR COUNTING NUMBER OF CHARACTERS
- TOUPPER(X) AND TOLOWER(X)- FOR ALTERING CASE

BASIC STRING

Exercise 1

Produce the string :"May,the force,be with,you“

Using paste() as seen in the previous example

DATA STRUCTURE AT A GLANCE

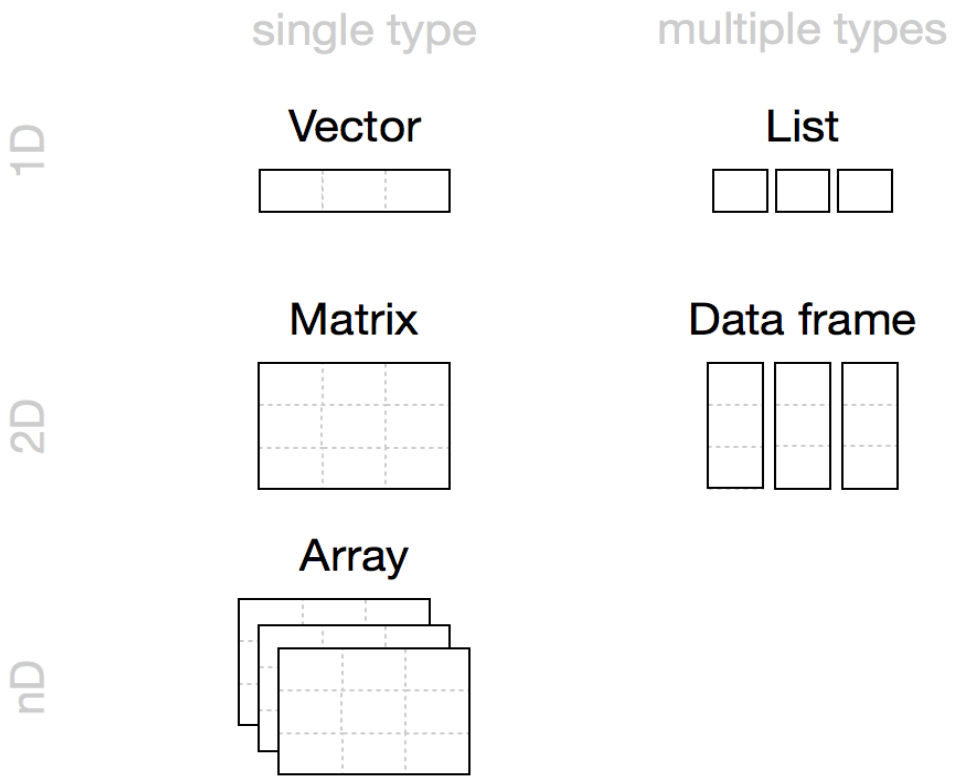
- Commonly used data structure
  - VECTORS
  - LISTS
  - MATRICES
  - ARRAYS
  - FACTORS
  - DATA FRAMES

Dimension	Type	
	Homogeneous	Heterogeneous
1d	Vector	List
2d	Matrix	Data Frame
nd	Array	N/A

From:* *Hadley Wickham's book Advanced R

- Build up some intuition now and we will go through each of them in detail later

DATA STRUCTURE AT A GLANCE



VECTORS

- As seen previously , use c() to declare vector

```
# Create a vector.
car<- c('BMW','TOYOTA',"AUDI")
print(car)
# Get the class of the vector.
print(class(car))
```

- Forms for creating numerical sequence

```
#Short from of sequence of numerical values with interval ==1
number<- 1:10
#Sequence of number with specific interval
number2<- seq(1,10, by=0.5)
```

- More on later slides

VECTORS

- Empty vector

```
y=vector(mode="logical",length=9)
z=vector(mode="numeric",length=4)
```

- Short form for creating repetitive numerical sequence

```
rep(1:4, 2)
rep(1:4, each = 2) # not the same
rep(1:4, c(2,2,2,2)) # same as second
rep(1:4, c(2,1,2,1))
rep(1:4, each = 2, len = 4) # first 4 only
rep(1:4, each = 2, len = 10) # 8 integers plus two recycled 1's
rep(1:4, each = 2, times = 3) # length 24, 3 complete replications
```

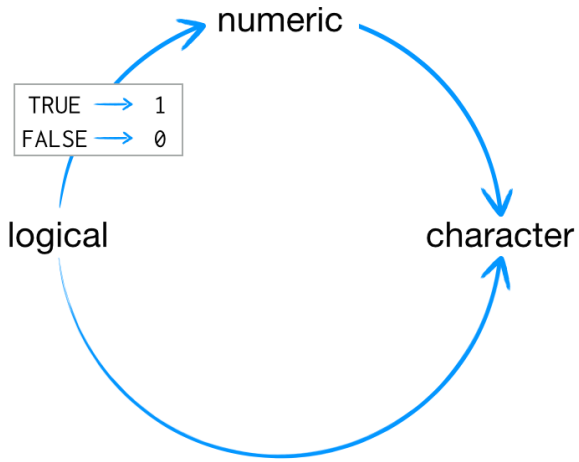
VECTORS

- What if:

```
# Create a vector.
data<- c('BMW','TOYOTA',1)
print(data)
# Get the class of the vector.
print(class(data))
# Create a vector.
data1<- c(TRUE,FALSE,1)
print(data)
# Get the class of the vector.
print(class(data))
```

VECTORS COERCION

- If a character string is present in as vector, R will convert everything else in the vector to character strings
- If a vector only contains logical values and numbers, R will convert the logical values to numbers; every TRUE becomes a 1, and every FALSE becomes a 0



LISTS

- Similar to vectors
- Contains many different types of elements
- Vectors contains one type of elements

```
# Create a list.
list1 <- list(c(2,5,3),21.3,sin)

# Print the list.
print(list1)

print(class(list))
```

MATRICES

- A matrix is a two-dimensional rectangular data set.
- As vector, element is selected in this form m[i][j]

```
# Create a matrix by row.
M <- matrix( c('a','a','b','c','b','a'), nrow = 2, ncol = 3, byrow = TRUE)
print(M)

# Create a matrix by column.
N <-matrix( c('a','a','b','c','b','a'), nrow = 2, ncol = 3, byrow = FALSE)
print(N)
# Create a numerical matrix.
N <-matrix( c(1:6), nrow = 2, ncol = 3, byrow = TRUE)
print(N)
```

MATRICES

- You can also create a matrix by using column binding and row binding functions:

```
B <- cbind(c(1, 2, 3), c(4, 5, 6));
print(B);
C <- rbind(c(1, 2, 3), c(4, 5, 6));
 print(C);
```

- Define the column and row names.

```
rownames = c("row1", "row2", "row3", "row4")
colnames = c("col1", "col2", "col3")
P <- matrix(c(3:14), nrow = 4, byrow = TRUE, dimnames =
list(rownames, colnames))
print(P)
#Change name of matrix
row.names(P)<-c("a","b","c","d")
row.names(P)<-c("a","b","c","d")
```

ARRAYS

- Arrays can be of any number of dimensions compared to 2D Matrix

 - *array(c(11:14, 21:24, 31:34), dim = c(2, 2, 3))*

- 3D, 4D , 5D example
- Naming of array must meet dimension of array

EXERCISE 2

- Create a 5 by 5 matrix

1	**3**	**5**	**7**	**9**
11	13	15	17	19
21	23	25	27	29
31	33	35	37	39
41	43	45	47	49

- Create the same matrix using cbind or rbind
- Create a 3D array has 3 elements with each has a 3*3 matrix

FACTORS

- Stores the distinct values of the elements in the vector as labels
- For all data types

```
# Create a vector.
apple_colors <-
c('green','green','yellow','red','red','red','green')

# Create a factor object.
factor_apple <- factor(apple_colors)

# Print the factor.
print(factor_apple)
print(nlevels(factor_apple))
```

FACTORS

- Apply the factor function with required order of the level.

- *new_factor_apple <- factor(factor_apple,levels = c("yellow","green","red"))*

- *print(new_factor_apple)*

DATA FRAMES

- Data frames are tabular data objects
- A list of vectors of equal length.

```
A <- data.frame(emp_id=c(1, 2, 3), names=c("John", "James",
                                           "Mary"), salary=c(111.1, 222.2, 333.3));
```

- Create Dataframe by csv

```
animal<-read.csv("AnimalData.csv")
```

OPERATORS

- Arithmetic Operators
- Relational Operators
- Logical Operators
- Assignment Operators
- Miscellaneous Operators(Introduced when needed)

ATHEMATIC OPERATORS

Operators	Meanings	Examples
+	Add	a<-1; c<-5 ;a+c v <- c(2,5.5,6) ; t <- c(8, 3, 4); v+t
-	Minus	c-a ; t-v
*	Multiply	c*a ; t*v
/	Divide	c/a ;t/v
%%	Reminder	c%%a ; t%%v
%/%	Integer quotient	c%/%a ; t%/%v
^	Power	c^a ; t^v

RELATIONAL OPERATORS

Each element of the first vector is compared with the corresponding element of the second vector. The result of comparison is a Boolean value.

Operators	Meanings	Examples
>	Greater	a<-1; c<-5 ;a>c ;c>a v <- c(2,5.5,6,9) t <- c(8,2.5,14,9); v>t
<	Less than	a<c ; t<v
==	Equal to (Not assignment!)	c==a ; t==v
<=	less than or equal to	c<=a ;t<=v
>=	Greater than or equal to	c>=a ; t>=v
!=	Not equal	c!=a ; t!=v

LOGICAL OPERATORS

It is applicable only to vectors of type logical, numeric or complex. All numbers greater than 1 are considered as logical value TRUE.

Operators	Meanings	Examples
&	AND	v <- c(3,1,TRUE,2+3i) t <- c(4,1,FALSE,2+3i) print(v&t)
|	OR	v <- c(3,0,TRUE,2+2i) t <- c(4,0,FALSE,2+3i) print(v|t)
!	NOT	v <- c(3,0,TRUE,2+2i) print(!v)
&&	AND for first element of vector	v <- c(3,0,TRUE,2+2i) t <- c(1,3,TRUE,2+3i) print(v&&t)
!!	NOT for first element of vector	v <- c(0,0,TRUE,2+2i) t <- c(0,3,TRUE,2+3i) print(v||t)

Q&A

THANK YOU!