Introduction to R

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Welcome

- This workshop is a part of UCONN SPORTS ANALYTICS SYMPOSIUM (UCSAS) 2022
- This workshop aims to give a quick tour of R
- All source codes of related documents of this workshop are in the GitHub repository: `https://github.com/fushengyy/UCSAS2022_intro_to_R`

About Me

- Fourth-year Ph.D. Student in Statistcs at UConn.
- Research Interests:
  - Time series analysis and extreme value analysis.
- Future goals:
  - Contribute to the broader field of environmental statistics.

Prerequisites

- A laptop with R/RStudio installed.
  - R can be downloaded for windows users here and for Mac users here
  - RStudio can be downloaded for all users here
- Little to no experience with R.

Outline

- R Basics
- R Data Structure
- Read and Write Data
- Data Management
- Brief Overview of "dplyr" and "ggplot2" Package

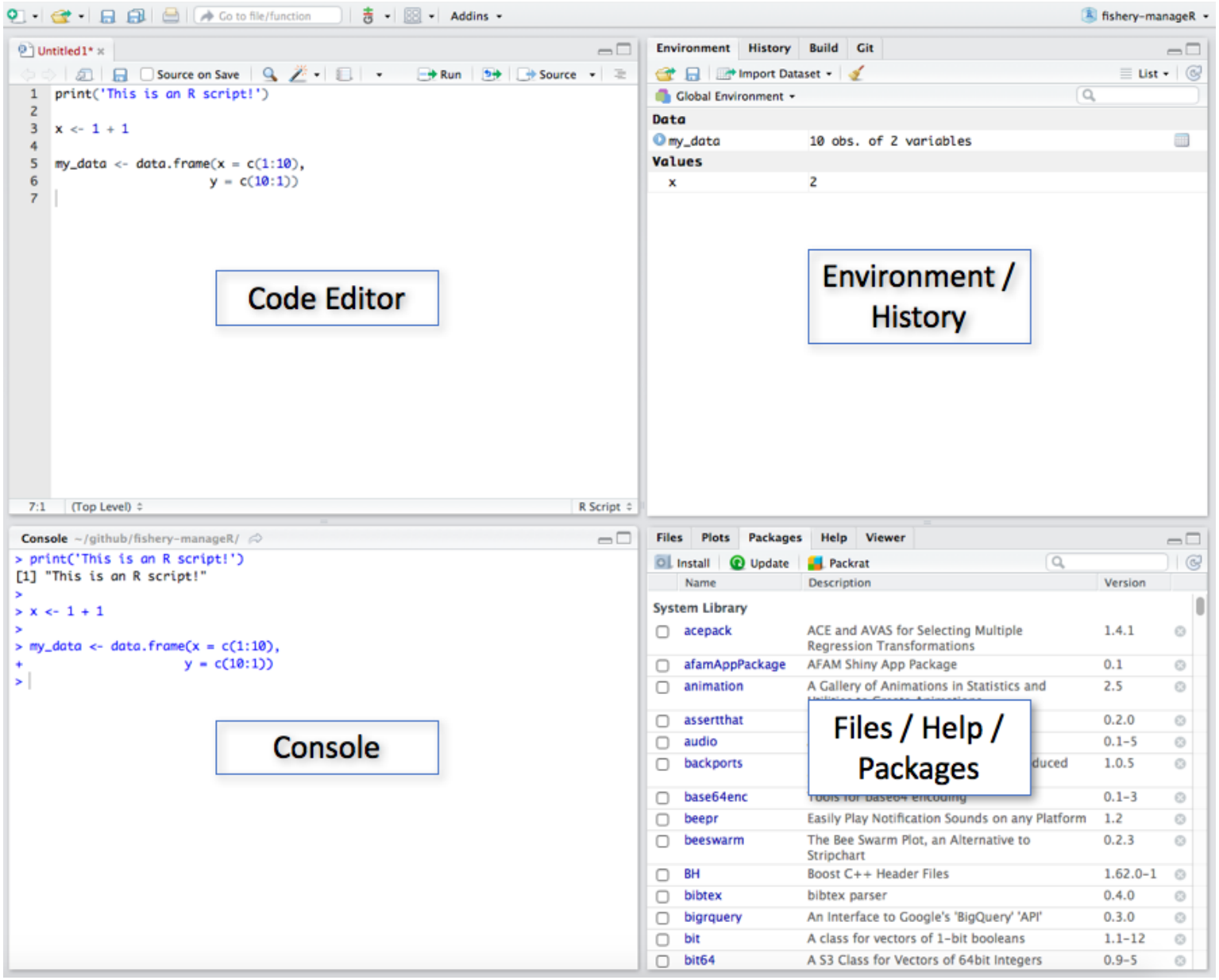
What is R?

- R is a free and open-source language and environment for statistical computing and graphics.
- First created by statisticians Ross Ihaka and Robert Gentleman in August 1993.
- Now supported by the R Core Team (formed in 1997) and the R Foundation for Statistical Computing (formed in 2003).

What is RStudio?

- RStudio is an integrated development environment (IDE) for R.
- It is available in two formats:
  - **RStudio Desktop**: a regular desktop application
  - RStudio Server: runs on a remote server and allows accessing RStudio using a web browser

RStudio Interface



R as a Calculator

$+$ Addition
$-$ Subtraction
$*$ Multiplication
$/$ Division
$\wedge$ or $**$ Exponentiation

Some built-in functions:
`sqrt()` Square root
`log()` Natural log
More here

Example:

```
3+8
exp(3)
sqrt(9)
```

Getting Help

The `help()` function and `?` operator in R provide access to the documentation pages for R functions, data sets, and other objects.

Example:
To get help with the `mean` function, we can use either `help(mean)` or `?mean`

Assignment Operators

Assign a value to a name using <-, ->, or =.

Example:

```
x <- 5
"Hello World!" -> y
z = 2022
```

Data Types

In R, there are 6 basic data types:

- Logical: boolean data type, can have two values: `TRUE` and `FALSE`.
- Numeric: all real numbers with or without decimal values.
- Integer: real values without decimal points
- Complex: purely imaginary values
- Character: character or string values. 'A' is a single character, "Apple" is a string. You can use single quotes '' or double quotes "".
- Raw: specifies values as raw bytes. This will NOT be discussed in this workshop.

Data Structures

R has many data structure. The most essential ones are

- Vector
- List
- Dataframe
- Matrix
- Array
- Factor

Data Structures (cont.)

- Vector: a collection of elements. Note the elements of a vector must be of the identical data type (Homogeneous). Vectors are one-dimensional data structures.
- List
- Dataframe
- Matrix
- Array
- Factor

Data Structures (cont.)

- Vectors
- List: a generic object consisting of an ordered collection of objects. A list can contain vectors or elements of unequal dimensions or different data types (Heterogeneous).
- Dataframe
- Matrix
- Array
- Factor

Data Structures (cont.)

- Vector
- List
- Dataframe: generic data objects of R which are used to store the tabular data. Dataframes are two-dimensional, heterogeneous data structures contain lists of vectors of equal lengths. Note a dataframe must have column names. Each column must have the identical number of items. Each item in a single column must be of the same data type. Different columns may have different data types.
- Matrix
- Array
- Factor

Data Structures (cont.)

- Vector
- List
- Dataframe
- Matrix: a rectangular arrangement of numbers in rows and columns. Matrices are two-dimensional, homogeneous data structures.
- Array
- Factor

Data Structures (cont.)

- Vector
- List
- Dataframe
- Matrix
- Array: the R data objects which store the data in more than two dimensions. Arrays are n-dimensional data structures.
- Factor

Data Structures (cont.)

- Vector
- List
- Dataframe
- Matrix
- Array
- Factor: the data objects which are used to categorize the data and store it as levels. They are useful for storing categorical data.

Data Structures (cont.)

	Homogeneous	Heterogeneous
1d	Vector	List
2d	Matrx	Dataframe
nd	Array	

Quiz 1

Consider $x = (7, 7, 9, 6, 55, 2)$

- What is the length of this vector?
- What are unique values of x?
- Sort the values of x.
- Frequency distribution of x.

Quiz 2

How would you describe the following three objects? What makes them different to 1:5?

```
x1 <- array(1:5, c(1, 1, 5))
x2 <- array(1:5, c(1, 5, 1))
x2 <- array(1:5, c(1, 5, 1))
```

Quiz 3

Let $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ and $B = \begin{bmatrix} 5 & 7 \\ 6 & 8 \end{bmatrix}$

Find

- dimensions of A and B;
- determinants of A and B;
- $A + B$;
- AB;
- A^{-1} and B^{-1}.

Function

- An R function is created by using the keyword "function".

- Basic syntax:

```
function_name <- function(arg_1, arg_2, ...) {
    Function body
}
```

- Components:

Function Name: the actual name of the function. It is stored in R environment as an object with this name.

Arguments: a placeholder. When a function is invoked, you pass a value to the argument. Arguments are optional; that is, a function may contain no arguments. Also arguments can have default values.

Function Body: contains a collection of statements that defines what the function does.

Return Value: the last expression in the function body to be evaluated.

Quiz 4

Write a function that takes x and y as inputs and returns the value y^x.

Loop

We use loop to deal with repeated tasks.

- **for** loop: the most commonly used loop structure when you want to repeat a task a defined number of times.
- **while** loop: used when you want to keep looping until a specific logical condition is satisfied (contrast this with the for loop which will always iterate through an entire sequence).

Condition

- **if** Statement: The *if* statement takes a condition; if the condition evaluates to *TRUE*, the R code associated with the *if* statement is executed.
- **if ... else ...** Statement: The code associated with the *else* statement gets executed whenever the condition of the *if* condition is *FALSE*.
- **if ... else if ... else** Statement: The *else if* condition is checked if the first condition is not satisfied. If the second condition is then met, then the code inside it is executed.

Quiz 5

Using the conditional statement, check whether -9 is divisible by 2 or by 3.

Read and Write Data from/to Local Directory

- Read data syntax:

```
read.table(file = "location_of_file",
           header = TRUE)
```

- Write/Save data syntax:

```
write.table(dataName,
            file = "location_of_file")
```

- Some useful functions:

```
read.csv(), read.csv2(),
write.csv(), write.csv2(),
etc.
```

Install and Load R Packages

- Install a package syntax:

```
install.packages("package_name")
```

- Load a package syntax:

```
library("package_name")
```

- Install and load "Lahman" package:

```
install.packages("Lahman")
library(Lahman)
```

"Lahman" package contains historical season-level baseball data for Major League Baseball going back to 1871.

Search and Read Datasets in a Package

- Search datasets from a package syntax:

```
data(package = "package_name")
```

- Read a particular dataset from a package syntax:

```
data("dataName", package = "package_name")
```

Dataframe

`str(Batting)`: Learn more about variables. (For more information about the dataset, check here.)
`names(Batting)`: Names of the dataset.
`head(Batting)`: Display the first few rows of the dataset.
`Batting[, 1:4]`: Display the first 4 columns of the dataset.
`Batting[1:4,]`: Display the first 4 rows of the dataset.
`Batting$playerID`: Display values of the variable "playerID".
`Batting[, c("playerID")]`: Display values of the variable "playerID".
`Batting[1:10, c("playerID", "yearID")]`: Display the first 10 elements of the variables "playerID" and "yearID".
`Batting$CS_SO <- Batting$CS + Batting$SO`: Create a new variable "CS_SO" by adding up values of variables "CS" and "SO".
`Batting[, c("CS", "SO", "CS_SO")]`: Display only "CS", "SO", and "CS_SO" of the updated dataset

Quiz 6

Using Batting dataset

- Display data from year 1900 only.
- Find total number of players and teams played through out all games in the dataset.
- Create a new dataframe "Batting1950" for year 1950 only.

Data Manipulation using dplyr

dplyr: a R package which provides a set of tools for efficiently manipulating datasets.

Data Manipulation using dplyr (cont.)

- Installation and loading:

```
install.packages("dplyr")
library(dplyr)
```

- Load dataset "Salaries" from package "Lahman":

```
data("Salaries", package = "Lahman")
head(Salaries)
```

Data Manipulation using dplyr (cont.)

- Remove league info (variable "lgID") from "Salaries". i.e. select all variables but "lgID":

```
salaries <- Salaries %>%
              select(playerID, yearID,
                     teamID, salary)
head(salaries)
```

- Join salary info and batting info together:

```
batting <- left_join(Batting, salaries,
                     by = c("playerID", "yearID",
                            "teamID"))
head(batting)
```

`left_join(a, b, by = "x1")`: Join matching rows from b to a. More join options check here.

- Rearrange orders of the dataset by multiple variables:

```
batting <- batting %>% arrange(playerID, yearID)
```

Quiz 7

- Using "Batting" dataset to find players who have a minimum of 25 base on balls before the year of 1900 and save to a new dataframe "player25".
- Rearrange these players based on base on balls in a descending order and save to a new dataframe "player25_ordered".

Visualization Using ggplot2

ggplot2: a R package dedicated to data visualization. It allows to build almost any type of chart.

Visualization Using ggplot2 (cont.)

- Installation and loading:

```
install.packages("ggplot2")
library(ggplot2)
```

Visualization Using ggplot2 (cont.)

- Build data we want to use:

```
year_data <- batting %>%
  filter(yearID == "2005")
```

Visualization Using ggplot2 (cont.)

- Scatterplot of Homeruns vs. Doubles in 2005:

```
ggplot(year_data, aes(x = X2B, y = HR)) +
  geom_point()
```

- Change label names and add title:

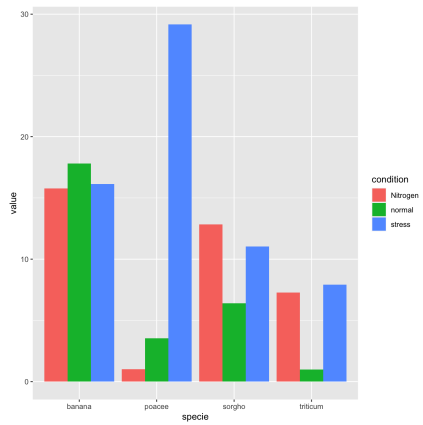
```
ggplot(year_data, aes(x = X2B, y = HR)) +
  geom_point() +
  labs(x = "Doubles", y = "Homeruns",
       title = "Scatterplot: Homeruns vs. Doubles")
```

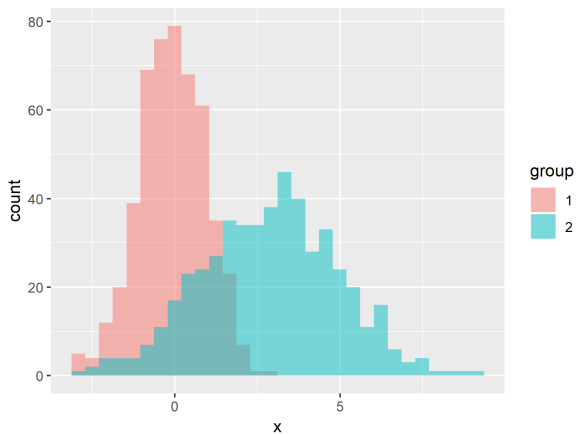
- Group by League (lgID):

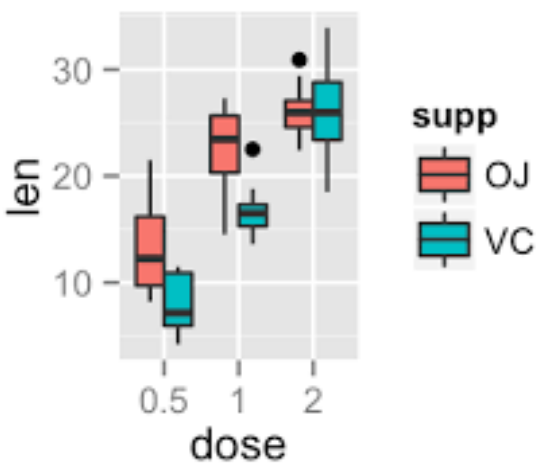
```
ggplot(year_data, aes(x = X2B, y = HR,
                      color = lgID)) +
  geom_point() +
  labs(x = "Doubles", y = "Homeruns",
       title = "Scatterplot: Homeruns vs. Doubles")
```

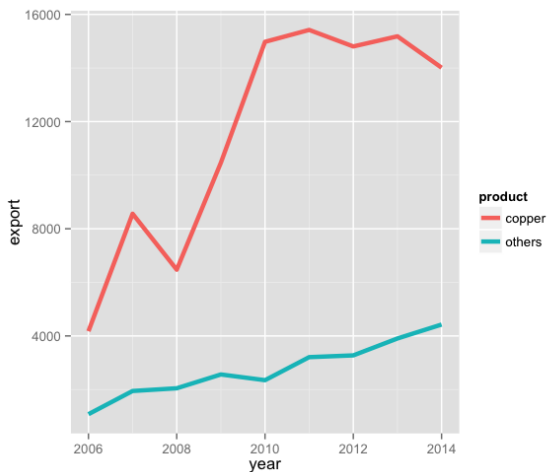
Visualization Using ggplot2 (cont.)

- Useful plots:
  - barplot: `geom_bar()`
  - histogram: `geom_histogram()`
  - boxplot: `geom_boxplot()`
  - line plot: `geom_line()`









Useful References

- R Programming for Data Science by Roger D. Peng
- An Introduction to R by W. N. Venables, D. M. Smith and the R Core Team
- R for Data Science by Hadley Wickham and Garrett Grolemund

Thank You!