CSE 578: Data Visualization (2020 Spring)
LAB 1 - (R) 1/23

1. R or Python?

- We know that R and Python both are open source programming languages.
- The major purpose of using R is for statistical analysis, on the other hand Python provide the more general approach to data science.
- R is having the most powerful communication libraries that are quite helpful in data science.
- In addition, R is equipped with many packages that are used to perform the data mining and time series analysis.
- If you use R and you want to perform some object-oriented function than you can't use it on R.
- On the other hand, Python is not suitable for statistical distributions.
- R is more functional, Python is more object-oriented.
- R has more data analysis built-in, Python relies on packages.
- R has more statistical support in general
- It's usually more straightforward to do non-statistical tasks in Python.

2. R as a calculator:

```
> 1+2
[1] 3
> 3^2
[1] 9

#Try built-in functions
> exp(2)-log(100)
[1] 2.783886

# Define a compound function
> sqrt(abs(-2))
[1] 1.414214
> a<-1
> b=2
> (a+b)^2
[1] 9

#Define a function z=f(x,y)
> f<-function(x, y) z<-(y^2-x^2)*pi
> print(f(1,2))
[1] 9.424778

#See what variables you have
> ls()
```

```
[1] "a"    "A"    "b"    "B"    "f"
```

#Remove a and b from working space

```
> rm(a,b) # Remove all with "rm(list=ls())"
> ls()
[1] "A"    "B"    "f"
```

3. Create Vectors in R:

```
> A<-c(2,3,5,7,11)
> B<-seq(100,108, by=2)
> B
[1] 100 102 104 106 108

> c(A,B)
 [1]   2   3   5   7  11 100 102 104 106 108

> A+B
[1] 102 105 109 113 119

> airports<-c("JFK","LGA","EWR","SFO")
> length(airports)
[1] 4

> airports[4] #How about airports[-4] ?
[1] "SFO"

> airports[1:3]
[1] "JFK" "LGA" "EWR"

> airports[c(2,4)]
[1] "LGA" "SFO"
```

Q1: What are the differences among vector, matrix, data frame, and factor?
Your answer should provide a concrete example in codes and annotations.

Solution:

1. **Vector:**
   A **vector** is what is called an array in all other programming languages except R — a collection of cells with a fixed size where all cells hold the same type (integers or characters or reals or whatever). The elements of a vector must all have the same mode or data type. You can have a vector consisting of three character strings (of mode character) or four integer elements (of mode integer), but not a vector with a mix of integer elements and character string elements.
   For e.g. x and y are vectors:

a. x <- c(5,7,9,7)
b. y <- c("a", "b", "c")

2. **Matrix:**
A **matrix** is a two-dimensional vector (fixed size, all cell types the same). All columns in a matrix must have the same mode(numeric, character, etc.) and the same length. The general format is:

```
mymatrix <- matrix(vector, nrow=r, ncol=c, byrow=FALSE,
dimnames=list(char_vector_rownames, char_vector_colnames))
```

For e.g.

```
# generates 5 x 4 numeric matrix
y<-matrix(1:20, nrow=5,ncol=4)
```

3. **Data Frame:**
A **data frame** is a matrix-like data structure in R, with two-dimensional rows and columns where each column may have a different mode or data type. For instance, one column may consist of numbers, and another column might have character strings.
For e.g.

```
1. kids <- c("John", "Mary")
2. ages <- c(5, 7)
3. d <- data.frame(kids, ages, stringsAsFactors = F)
4. d
5.   kids ages
6. 1 John  5
7. 2 Mary  7
```

Here, d is a simple data frame consisting of a character vector "kids" and a numeric vector "ages".

4. **Factor:**
An R **factor** might be viewed simply as a vector with a bit of extra information that consists of a record of the distinct values in that vector called levels. The motivation for factors comes from the notion of nominal / categorical variables in statistics. These values are non-numerical in nature, corresponding to categories such as male / female or high / medium / low, although they may be coded using numbers.
For e.g.

```
1. x <- c(5,7,9,7)
2. xf <- factor(x)
3. xf
4. [1] 5 7 9 7
```

5. Levels: 5 7 9

The distinct values in xf: 5, 7 and 9 are the levels here. Let's take a look inside:

1. str(xf)
2. Factor w/ 3 levels "5","7","9": 1 2 3 2
3. unclass(xf)
4. [1] 1 2 3 2
5. attr(,"levels")
6. [1] "5" "7" "9"

The core of xf here is not (5, 7, 9, 7) but rather (1, 2, 3, 2) i.e. (level-1, level-2, level-3, level-2). So, the data has been recoded by level.

R will treat factors as nominal variables and ordered factors as ordinal variables in statistical proceedures and graphical analyses. You can use options in the **factor( )** and **ordered( )** functions to control the mapping of integers to strings (overiding the alphabetical ordering).

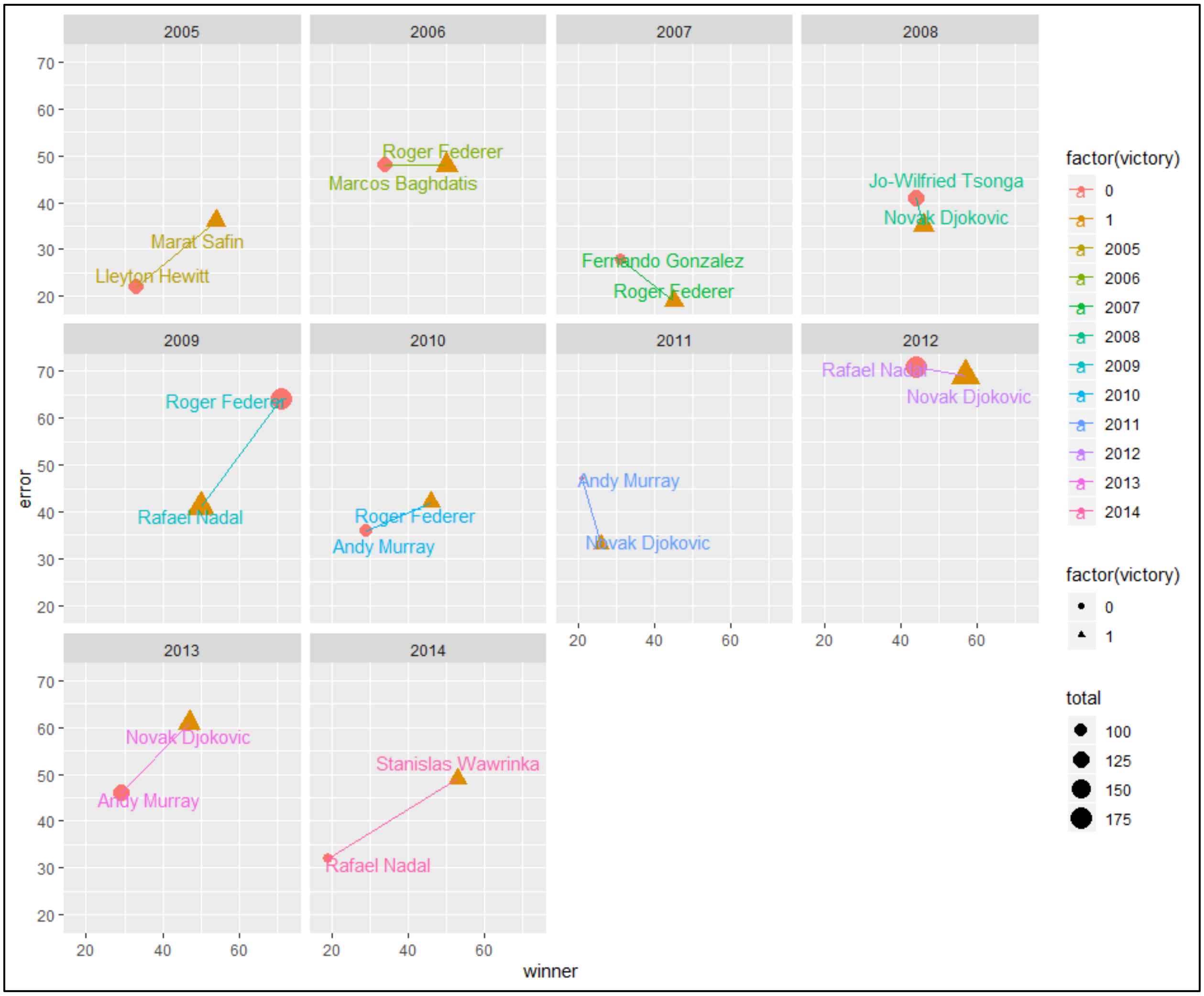
Source: https://www.statmethods.net/input/datatypes.html , https://jamesmccaffrey.wordpress.com/2016/05/02/r-language-vectors-vs-arrays-vs-lists-vs-matrices-vs-data-frames/ , https://www.quora.com/What-is-the-difference-between-Vector-Factor-and-DataFrames-in-R , http://adv-r.had.co.nz/Data-structures.html ,

4. Exploratory Analysis:

```
p <- ggplot(sample, aes(winner, error))
```

```
p + geom_point(aes(shape=factor(victory),size=total,colour=factor(victory)))+
geom_text_repel(aes(colour=factor(year),label=player), position = position_ji
tter(width=5, height=1.5) ) + facet_wrap(~year) + geom_line(aes(colour=factor
(year)))
```

Code Explaination:


2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Marat Safin
Lleyton Hewitt
Roger Federer
Marcos Baghdatis
Fernando Gonzalez
Roger Federer
Jo-Wilfried Tsonga
Novak Djokovic
Roger Federer
Rafael Nadal
Roger Federer
Andy Murray
Andy Murray
Novak Djokovic
Rafael Nadal
Novak Djokovic
Novak Djokovic
Andy Murray
Stanislas Wawrinka
Rafael Nadal
error
winner
factor(victory)
0
1
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
factor(victory)
0
1
total
100
125
150
175

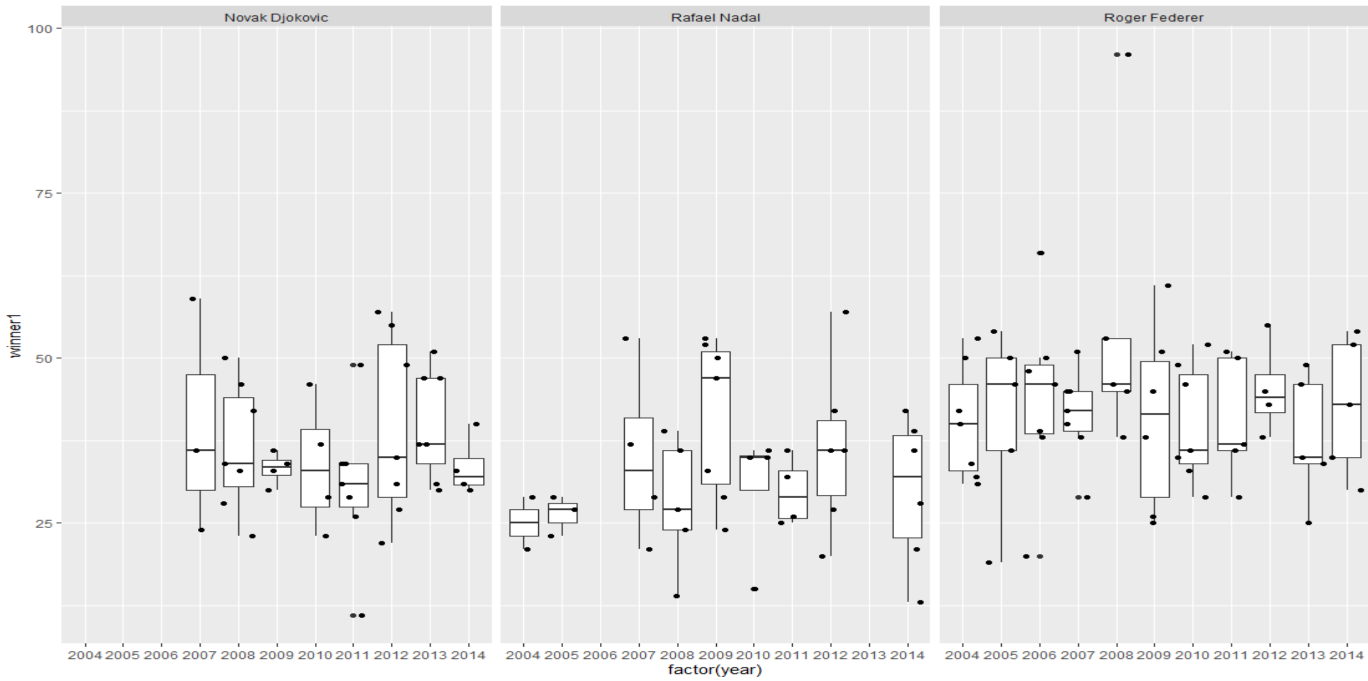
Q2: Come up with another assumption and vision the outcome may be in a similar comparative small multiples chart?
Ans:

Assumption: High return, high breaks, high total = wins the match

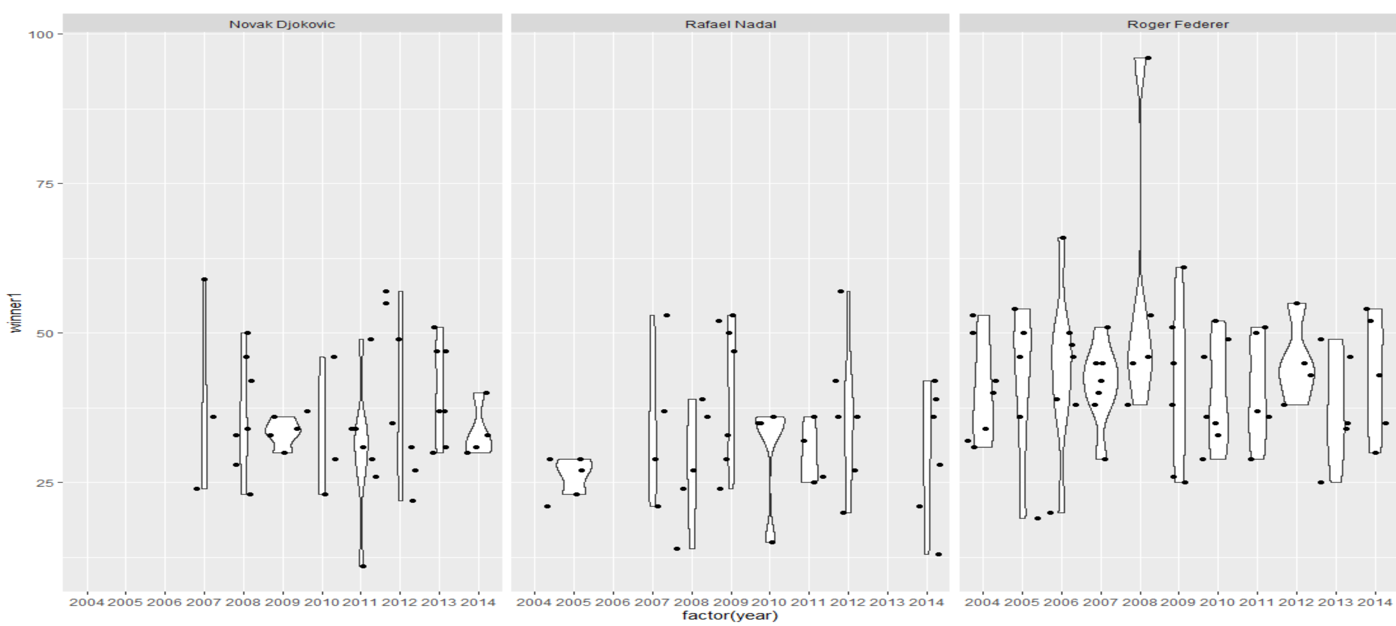
```
p <- ggplot(sample, aes(return,break.))

p + geom_point(aes(shape=factor(victory),size=total,color=ifelse((victory==0)
,"lose","win")))+ geom_text_repel(aes(label=player, color=ifelse((victory==0)
,"lose","win")), position = position_jitter(width=5, height=1.5),vjust=1.8) +
facet_wrap(~year) + scale_shape_manual(labels = c("Lose", "Win"),values=c(13,
21)) + labs(title = "Tennis Finals\n", color = "Color\n", shape="Shape\n") +
geom_line()
```

5. Deeper Analysis (Modeling):

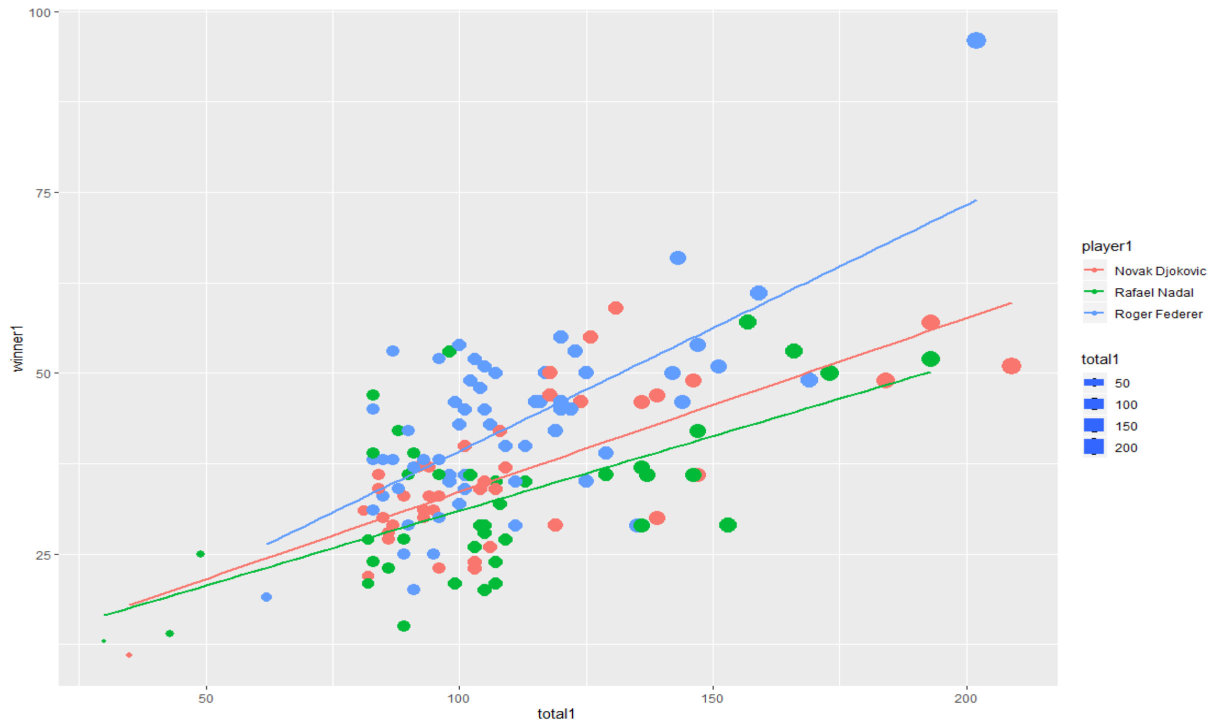
```
#only look at the big 3 players
p <- ggplot(big3, aes(factor(year), winner1))
p + geom_boxplot() + facet_grid(~player1)+ geom_jitter(height = 0)
```



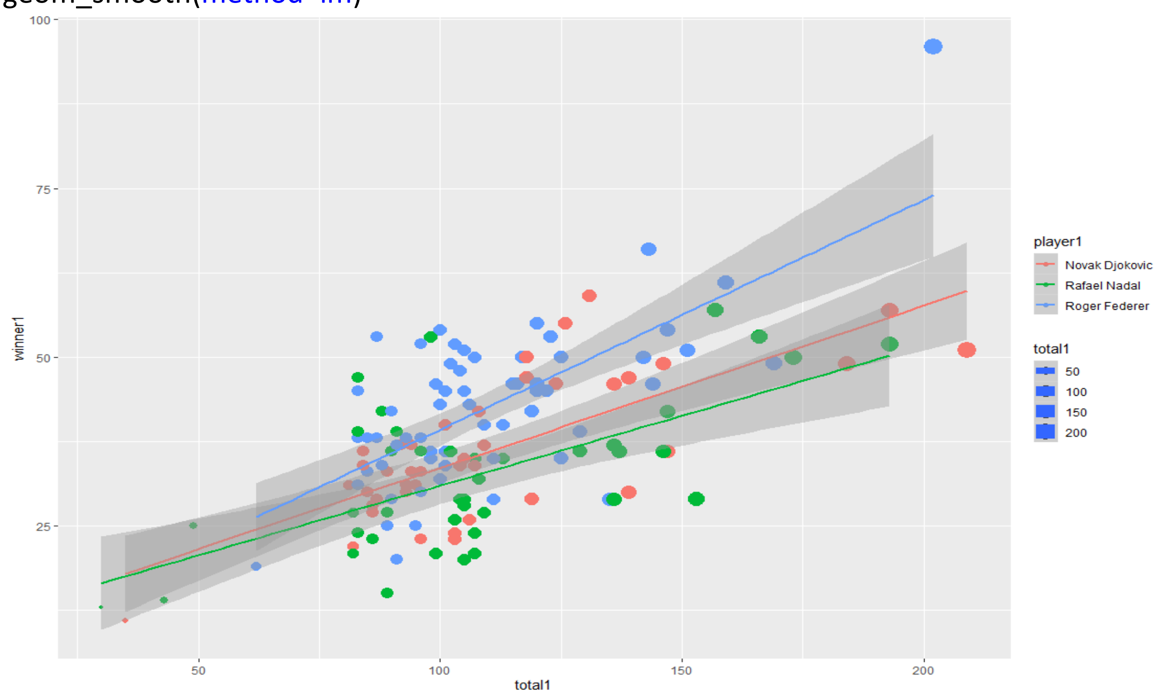

```
# distribution and density
p + geom_violin() +facet_grid(~player1)+ geom_jitter(height = 0)
```



```
# regression line
ggplot(big3, aes(x=total1, y=winner1, size=total1, color=player1)) +
geom_point()+geom_smooth(method=lm, se=F)
```



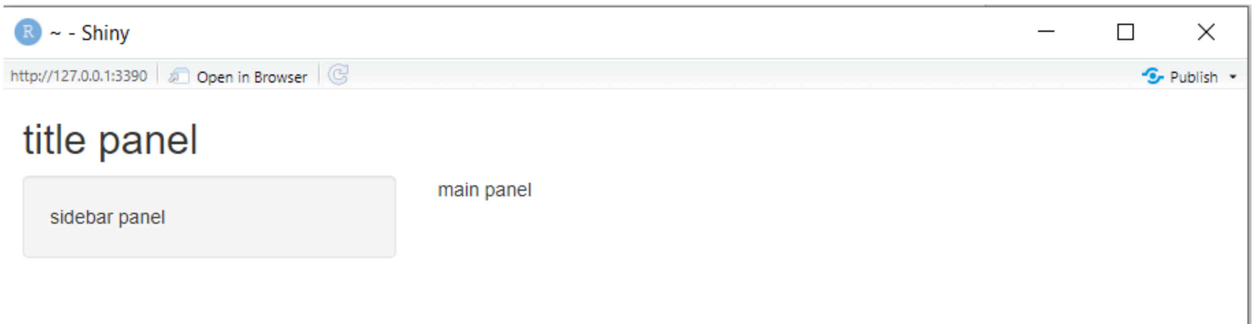

```
# regression + prediction
ggplot(big3, aes(x=total1, y=winner1, size=total1, color=player1)) + geom_point()+
geom_smooth(method=lm)
```



6. Interactive Visualization with R: Shiny

Example 1:

```
ui <- fluidPage(titlePanel("title panel"),sidebarLayout(sidebarPanel("sidebar panel"),mainPanel("main panel")))
server <- function(input,output) {}
shinyApp(ui=ui,server=server)
```



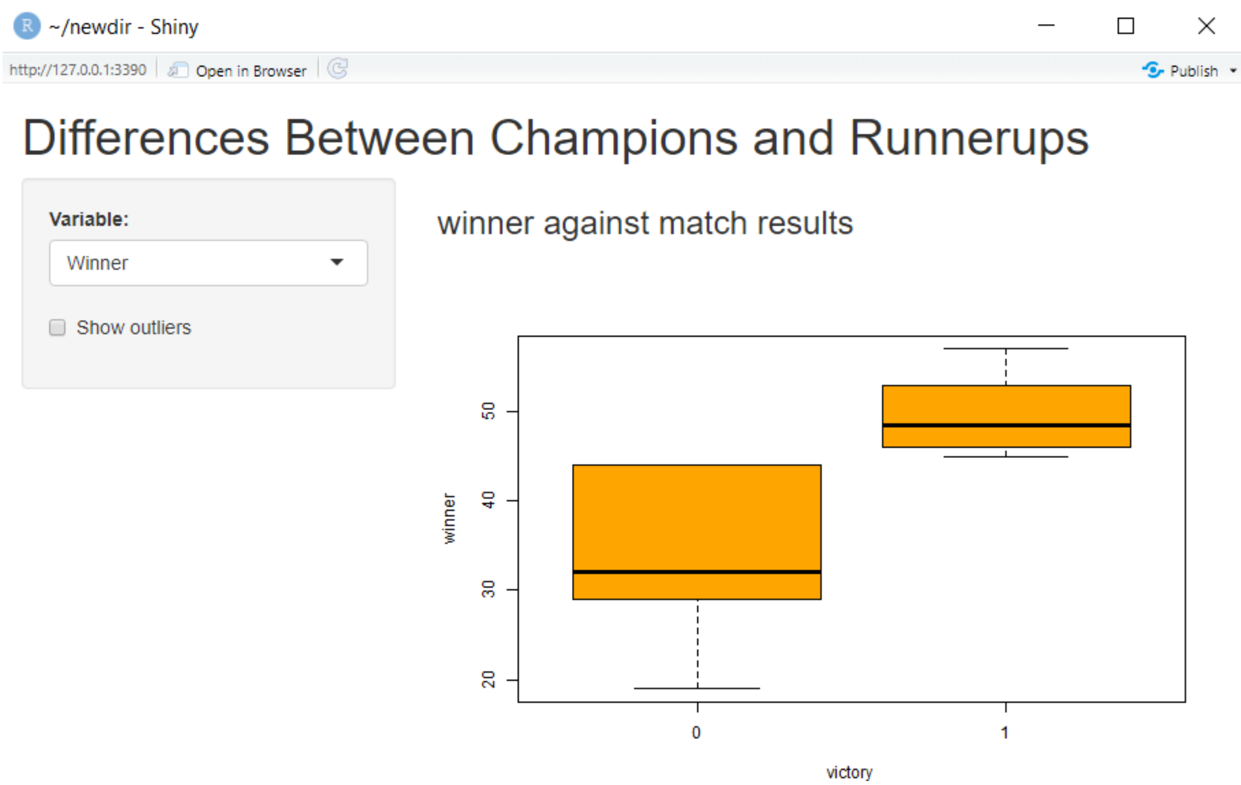
Example 2: Create two files ui.R and server.R and save them in a new folder “newdir”

```
#ui.R file code
library(shiny)
shinyUI (
 pageWithSidebar
 (
  #Specify Application title
  headerPanel ("Differences Between Champions and Runnerups"),
  #Sidebar with controls to select the variable to plot against match result
  sidebarPanel
  ( selectInput ("variable", "Variable:", list("Winner" = "winner",
                                               "Error" = "error",
                                               "Total" = "total")
  ),
   # Add an optional input: to specify whether outliers should be displayed
   checkboxInput ("outliers", "Show outliers", FALSE)
  ),
  #Show the caption and plot of the requested variable against match result as outputs
  mainPanel (h3(textOutput("caption")),
   plotOutput("tennisPlot")
  ) #
 ) # pageWithSidebar end
) #UI end


#server.R file code
library(shiny)
```

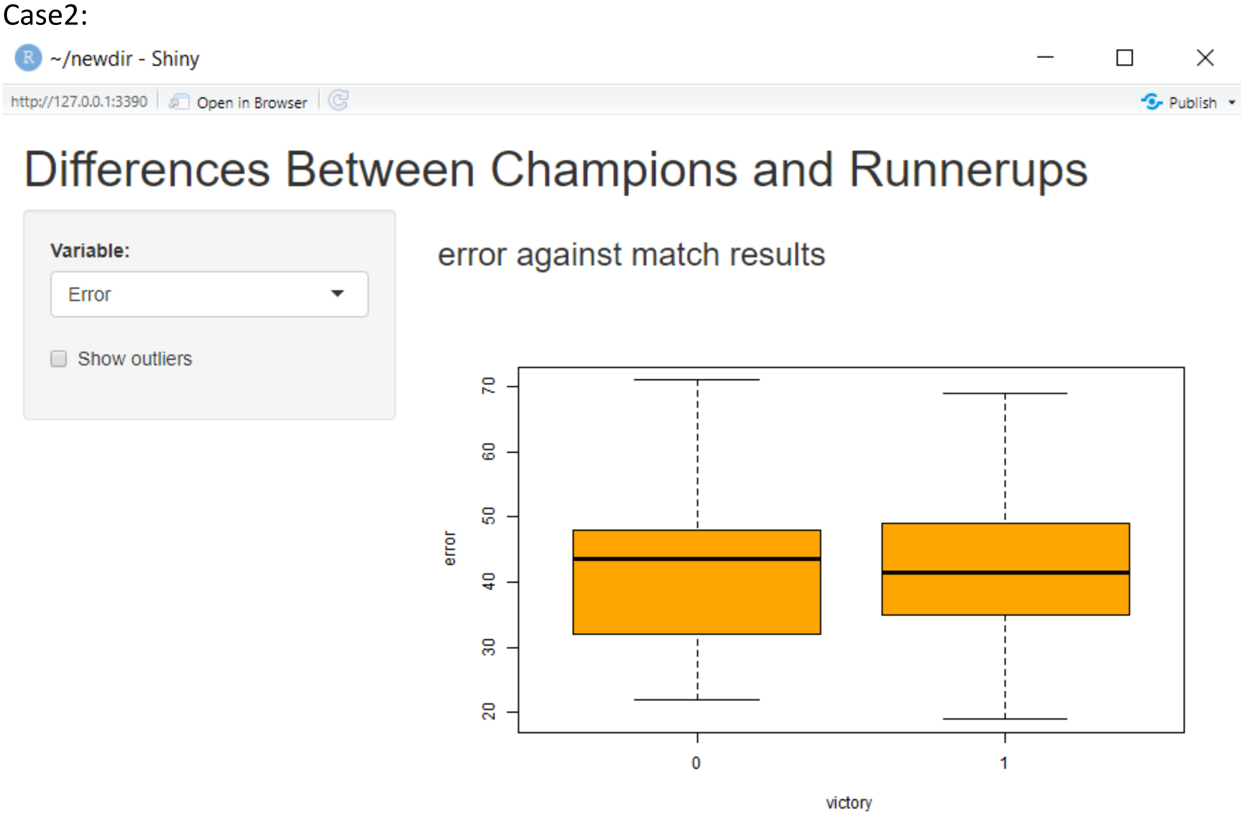
```
shinyServer(function(input, output)
{
  # Construct the formula for the title of the plot
  formulaText <- reactive(
    { paste(input$variable, "against match results") }
  )
  # Return the formula text for printing as a caption
  output$caption <- renderText (
    { formulaText() }
  )
  #Generate a boxplot of requested variable against result and include outliers if requested
  output$tennisPlot <- renderPlot(
    { #Construct a formula for the plot
      boxplot(as.formula(paste(input$variable, "~victory" )),
              data = sample,
              outline = input$outliers,
              col="orange")
    }
  )
}
)

# To run the application
runApp("newdir") //here newdir is the name of the folder where ui.R and server.R are stored
```

Output:

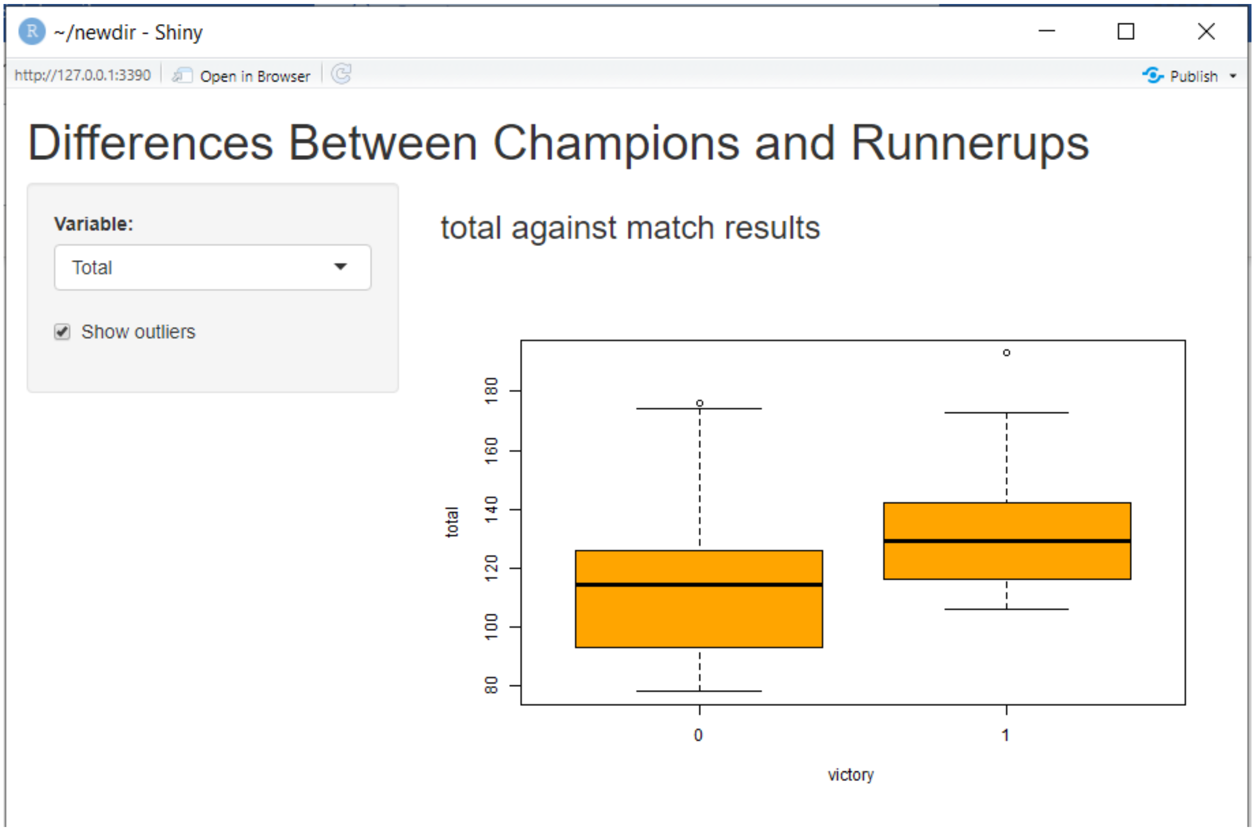
Case 1:


~/newdir - Shiny
http://127.0.0.1:3390
Open in Browser
Publish
Differences Between Champions and Runnerups
Variable:
Winner
Show outliers
winner against match results
winner
20
30
40
50
0
1
victory

Case2:


~/newdir - Shiny
http://127.0.0.1:3390
Open in Browser
Publish
Differences Between Champions and Runnerups
Variable:
Error
Show outliers
error against match results
error
20
30
40
50
60
70
0
1
victory

Case 3:


~/newdir - Shiny
http://127.0.0.1:3390
Open in Browser
Publish
Differences Between Champions and Runnerups
Variable:
Total
Show outliers
total against match results
total
80
100
120
140
160
180
0
1
victory