Interactive Visualization in R Workshop

Today's Goals

1. Create two Shiny Apps
2. Publish a Shiny App in shinyapps.io
3. Familiarize with resources to learn Shiny and other interactive packages

Today Agenda

1. Work with default example in R
2. Take Break
3. Work with another example using frmgham.csv data

Instructors

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What is Interactive plot?

- Some examples: Tableau , Power IB
- In R:
  - Shiny
  - Plotly
  - Highcharter
  - ….
- In this workshop, we will focus on Shiny

Shiny is becoming a skill employers are looking for

The incumbent tasks would include the following:

Data manipulation : Compile and maintain large databases of macro-financial time series for a wide range of countries, automatize data treatment and data harmonization, ensure data quality across countries and time series.
Data visualization: Design and prepare intuitive charts, tables, diagrams and organize them within dashboards and chartpacks. Integrate visual output within reports and presentations
Data analysis: apply cutting hedge quantitative methods in financial econometrics and inferential statistics under the guidance of MCMCO experts. Deploy quantitative tools for operational use, such as forecasting, scenario simulation and policy analysis on a wide range of countries. The candidate should be familiar with the econometrics/statistical literature, be able to read academic articles and implement them for concrete policy work.

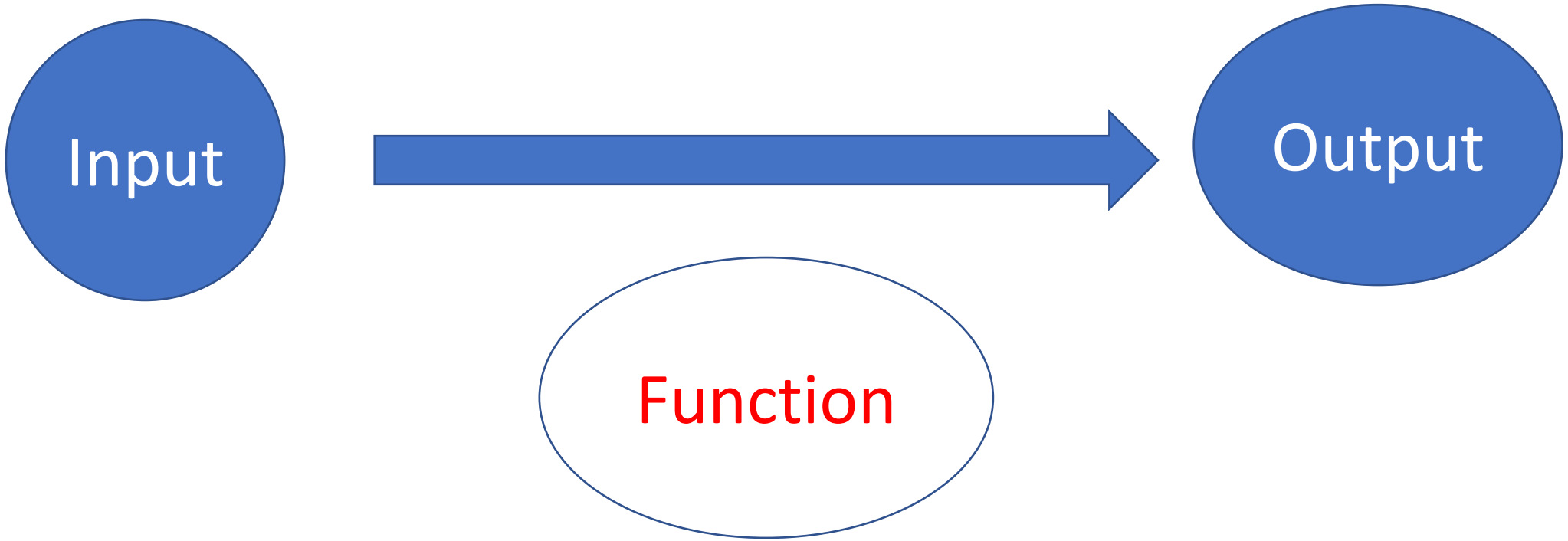
Finally, the candidate should be able to present and explain the quantitative results to different people, including to non-specialists.

Qualifications:

- At least a bachelor's degree in Economics, Finance, Mathematics (pure or applied), Data Science or Computer Science. A master's degree would be a plus.
- Proficiency in MS office suite, including MS Excel and VBA.
- Advanced proficiency in Python or R for data science applications, econometrics estimation and tasks automation
- Familiarity with data visualization tools such Plotly, Bokeh, Shiny, Tableau or Prezi would be a plus.
- Familiarity with database management tools such as SQL, SQLite, etc. would be a plus.

Department:
MCMCO Monetary and Capital Markets Dept. Central Bank Operations

How does interactive plot work?



What is Shiny?

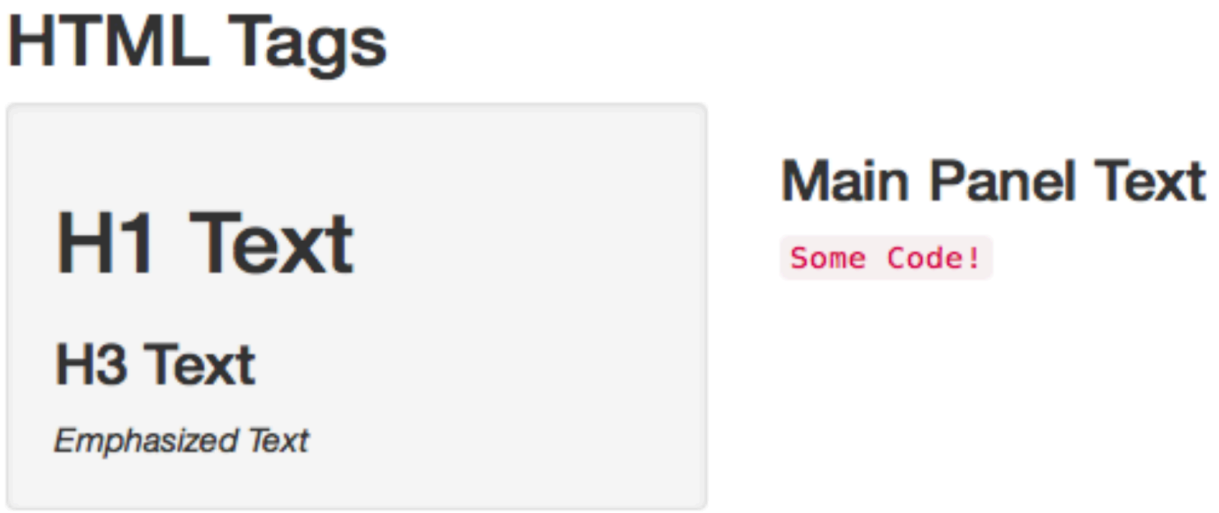
- Shiny is a web application framework for R.
- Shiny allows you to create a graphical interface so that users can interact with your visualizations, models, and algorithms without needing to know R themselves.
- However, to build a good Shiny App, you need some knowledge of:
  - HTML
  - R

Shiny Project:

- A shiny project CONSISTS OF a directory containing at least two files:
  - ui.R (user interface) : controls how your app looks.
  - server.R : controls what your app does.

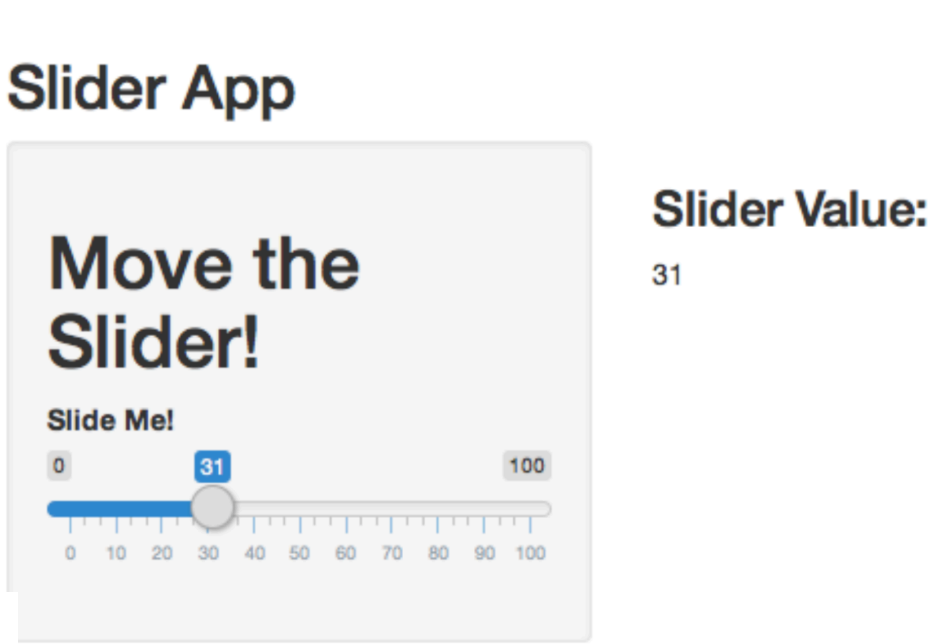
Example 1: ur.R


```
library(shiny)
shinyUI(fluidPage(
  titlePanel("HTML Tags"),
  sidebarLayout(
    sidebarPanel(
      h1("H1 Text"),
      h3("H3 Text"),
      em("Emphasized Text")
    ),
    mainPanel(
      h3("Main Panel Text"),
      code("Some Code!")
    )
  )
))
```



Example 2


```
library(shiny)
shinyUI(fluidPage(
  titlePanel("Slider App"),
  sidebarLayout(
    sidebarPanel(
      h1("Move the Slider!"),
      sliderInput("slider1", "Slide Me!", 0, 100, 0
    ),
    mainPanel(
      h3("Slider Value:"),
      textOutput("text")
    )
  )
))
```




```
library(shiny)
shinyServer(function(input, output) {
  output$text <- renderText(input$slider1)
})
```

Other Input

Inputs

collect values from the user

Access the current value of an input object with **input$<inputId>**. Input values are **reactive**.

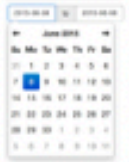
Action — **actionButton**(inputId, label, icon, …)

Link — **actionLink**(inputId, label, icon, …)

Choice 1 / Choice 2 / Choice 3 — **checkboxGroupInput**(inputId, label, choices, selected, inline)

Check me — **checkboxInput**(inputId, label, value)

dateInput(inputId, label, value, min, max, format, startview, weekstart, language)



dateRangeInput(inputId, label, start, end, min, max, format, startview, weekstart, language, separator)

Choose File — **fileInput**(inputId, label, multiple, accept)

1 — **numericInput**(inputId, label, value, min, max, step)

••••••••• — **passwordInput**(inputId, label, value)

Choice A / Choice B / Choice C — **radioButtons**(inputId, label, choices, selected, inline)

Choice 1 / Choice 1 / Choice 2 — **selectInput**(inputId, label, choices, selected, multiple, selectize, width, size) (also selectizeInput())

0 5 10 — **sliderInput**(inputId, label, min, max, value, step, round, format, locale, ticks, animate, width, sep, pre, post)

Apply Changes — **submitButton**(text, icon)
(Prevents reactions across entire app)

Enter text — **textInput**(inputId, label, value)

Let's Work in R

Break
Until 10:52am

Another Example with frmgham.csv

My Shiny App

I want to:

- Display my data
- Display a scatter plot that allow users to:
  - Choose any of the two variables
  - Change color
  - Fit regression
- Display Summary Statistics
- Display Regression Line

My Shiny App

I want to:

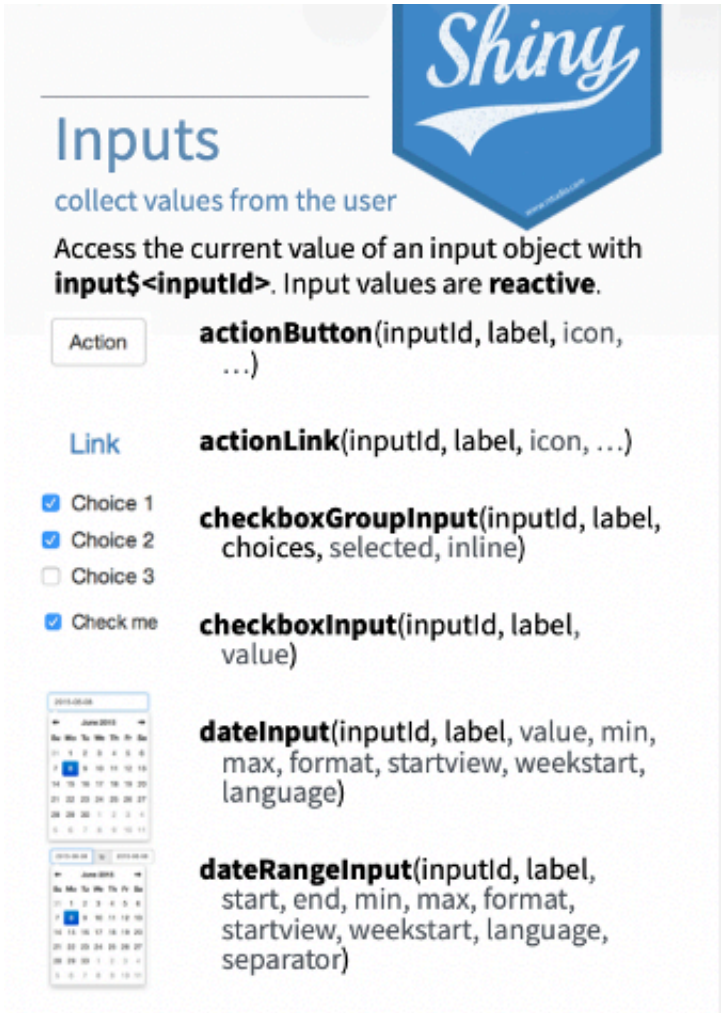
- Display my data
- Display a scatter plot that allow users to:
  - Choose any of the two variables
  - Change color
  - Fit regression
- Display Summary Statistics
- Display Regression Line

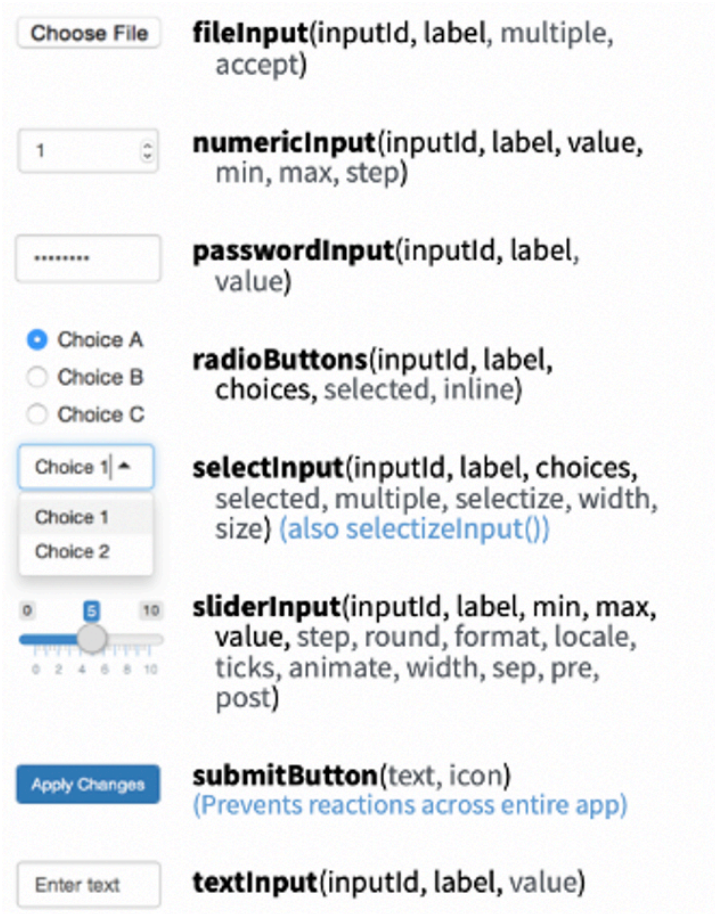
Inputs & Outputs

- Input:
  - input$x
  - input$y
  - input$color
  - input$line
- Output:
  - output$mytable
  - output$plot
  - output$summary
  - output$regression

Types of Input and Output

- Input:
  - input$x
  - input$y
  - input$color
  - input$line
- Output:
  - output$mytable
  - output$plot
  - output$summary
  - output$regression





Let's have a quick look

R Shinny Workshop

Choose X

TOTCHOL

Choose Y

SYSBP

Choose color for plot

- red
- blue
- green

Fit a regression line

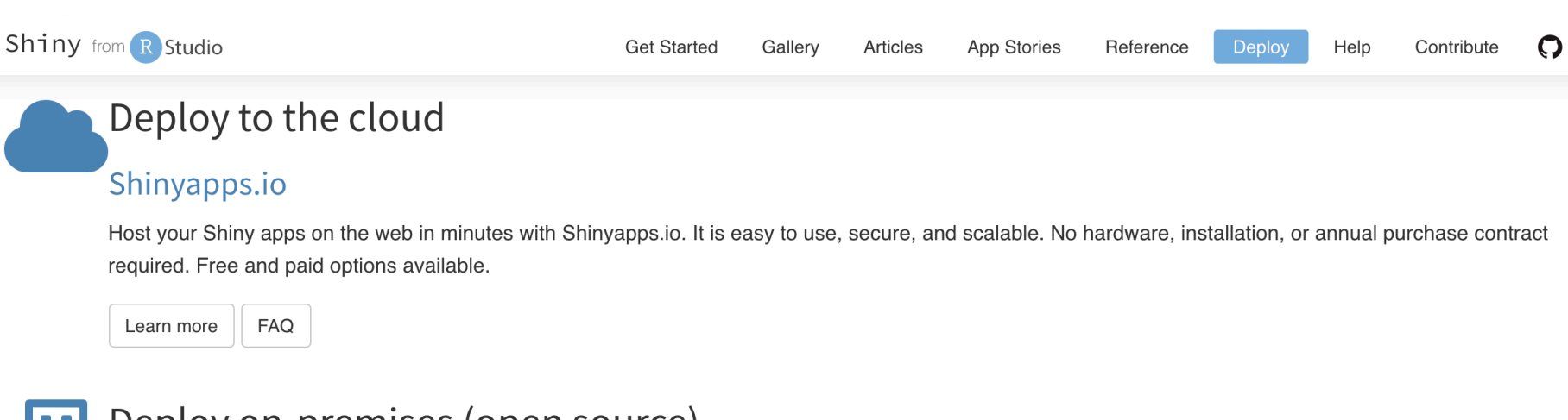
Table | Plot | Summary | Result

Show 10 entries Search:

	TOTCHOL	SYSBP	DIABP	HEARTRTE	BMI	GLUCOSE
1	195	106	70	80	26.97	77
2	209	121	66	69		92
3	250	121	81	95	28.73	76
4	260	105	69.5	80	29.43	86
5	237	108	66	80	28.5	71
6	245	127.5	80	75	25.34	70
7	283	141	89	75	25.34	87
8	225	150	95	65	28.58	103
9	232	183	109	60	30.18	89
10	285	130	84	85	23.1	85

Showing 1 to 10 of 11,627 entries Previous 1 2 3 4 5 … 1163 Next

Publishing Your App



Resources to learn Shiny

- Tutorial : https://shiny.rstudio.com/tutorial/
- Gallery : https://shiny.rstudio.com/gallery/
- Cheat sheet : https://shiny.rstudio.com/articles/cheatsheet.html
- LinkedIn Learning
- Library Resources

Shiny : : CHEAT SHEET

Basics

A **Shiny** app is a web page (**UI**) connected to a computer running a live R session (**Server**)

Users can manipulate the UI, which will cause the server to update the UI's displays (by running R code).

APP TEMPLATE

Begin writing a new app with this template. Preview the app by running the code at the R command line.

```
library(shiny)
ui <- fluidPage()
server <- function(input, output){}
shinyApp(ui = ui, server = server)
```

- **ui** - nested R functions that assemble an HTML user interface for your app
- **server** - a function with instructions on how to build and rebuild the R objects displayed in the UI
- **shinyApp** - combines `ui` and `server` into an app. Wrap with **runApp()** if calling from a sourced script or inside a function.

SHARE YOUR APP

The easiest way to share your app is to host it on shinyapps.io, a cloud based service from RStudio

1. Create a free or professional account at **http://shinyapps.io**
2. Click the **Publish** icon in the RStudio IDE or run:
   rsconnect::deployApp("<path to directory>")

Build or purchase your own Shiny Server
at www.rstudio.com/products/shiny-server/

RStudio

Building an App

Complete the template by adding arguments to fluidPage() and a body to the server function.

Add inputs to the UI with *Input() functions

Add outputs with *Output() functions

Tell server how to render outputs with R in the server function. To do this:

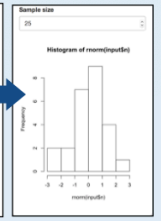
1. Refer to outputs with **output$<id>**
2. Refer to inputs with **input$<id>**
3. Wrap code in a **render*()** function before saving to output

```
library(shiny)

ui <- fluidPage(
  numericInput(inputId = "n",
    "Sample size", value = 25),
  plotOutput(outputId = "hist")
)

server <- function(input, output) {
  output$hist <- renderPlot({
    hist(rnorm(input$n))
  })
}

shinyApp(ui = ui, server = server)
```



Save your template as **app.R**. Alternatively, split your template into two files named **ui.R** and **server.R**.

```
library(shiny)
ui <- fluidPage(
  numericInput(inputId = "n",
    "Sample size", value = 25),
  plotOutput(outputId = "hist")
)
server <- function(input, output) {
  output$hist <- renderPlot({
    hist(rnorm(input$n))
  })
}
shinyApp(ui = ui, server = server)
```

```
# ui.R
fluidPage(
  numericInput(inputId = "n",
    "Sample size", value = 25),
  plotOutput(outputId = "hist")
)
```

```
# server.R
function(input, output) {
  output$hist <- renderPlot({
    hist(rnorm(input$n))
  })
}
```

ui.R contains everything you would save to ui.

server.R ends with the function you would save to server.

No need to call **shinyApp()**.

Save each app as a directory that holds an **app.R** file (or a **server.R** file and a **ui.R** file) plus optional extra files.

The directory name is the name of the app

(optional) defines objects available to both ui.R and server.R

(optional) used in showcase mode

(optional) data, scripts, etc.

(optional) directory of files to share with web browsers (images, CSS, .js, etc.) Must be named "**www**"

Launch apps with `runApp(<path to directory>)`

Outputs - render*() and *Output() functions work together to add R output to the UI

	works with	
DT::**renderDataTable**(expr, options, callback, escape, env, quoted)		**dataTableOutput**(outputId, icon, …)
renderImage(expr, env, quoted, deleteFile)		**imageOutput**(outputId, width, height, click, dblclick, hover, hoverDelay, inline, hoverDelayType, brush, clickId, hoverId)
renderPlot(expr, width, height, res, …, env, quoted, func)		**plotOutput**(outputId, width, height, click, dblclick, hover, hoverDelay, inline, hoverDelayType, brush, clickId, hoverId)
renderPrint(expr, env, quoted, func, width)		**verbatimTextOutput**(outputId)
renderTable(expr,…, env, quoted, func)		**tableOutput**(outputId)
renderText(expr, env, quoted, func)		**textOutput**(outputId, container, inline)
renderUI(expr, env, quoted, func)	&	**uiOutput**(outputId, inline, container, …) **htmlOutput**(outputId, inline, container, …)

Inputs

collect values from the user

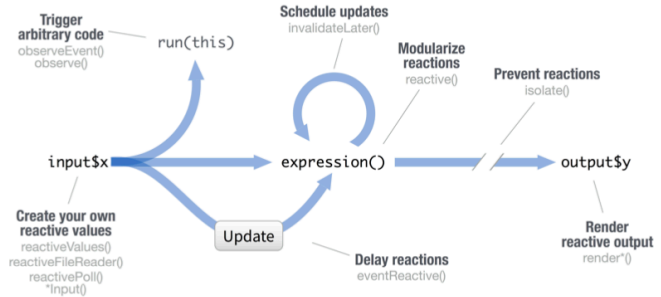
Access the current value of an input object with **input$<inputId>**. Input values are **reactive**.

Action	**actionButton**(inputId, label, icon, …)
Link	**actionLink**(inputId, label, icon, …)
Choice 1 Choice 2 Choice 3	**checkboxGroupInput**(inputId, label, choices, selected, inline)
Check me	**checkboxInput**(inputId, label, value)
	dateInput(inputId, label, value, min, max, format, startview, weekstart, language)
	dateRangeInput(inputId, label, start, end, min, max, format, startview, weekstart, language, separator)
Choose File	**fileInput**(inputId, label, multiple, accept)
1	**numericInput**(inputId, label, value, min, max, step)
•••••••	**passwordInput**(inputId, label, value)
Choice A Choice B Choice C	**radioButtons**(inputId, label, choices, selected, inline)
Choice 1 Choice 1 Choice 2	**selectInput**(inputId, label, choices, selected, multiple, selectize, width, size) (also selectizeInput())
0 5 10	**sliderInput**(inputId, label, min, max, value, step, round, format, locale, ticks, animate, width, sep, pre, post)
Apply Changes	**submitButton**(text, icon) (Prevents reactions across entire app)
Enter text	**textInput**(inputId, label, value)

Interactive Visualization in R

Reactivity

Reactive values work together with reactive functions. Call a reactive value from within the arguments of one of these functions to avoid the error `Operation not allowed without an active reactive context.`



CREATE YOUR OWN REACTIVE VALUES

```
# example snippets

ui <- fluidPage(
 textInput("a","","A")
)

server <-
function(input,output){
 rv <- reactiveValues()
 rv$number <- 5
}
```

***Input() functions** (see front page)

reactiveValues(...)

Each input function creates a reactive value stored as **input$<inputId>**

reactiveValues() creates a list of reactive values whose values you can set.

RENDER REACTIVE OUTPUT

```
library(shiny)
ui <- fluidPage(
 textInput("a","","A"),
 textOutput("b")
)

server <-
function(input,output){
 output$b <-
  renderText({
   input$a
  })
}

shinyApp(ui, server)
```

render*() functions (see front page)

Builds an object to display. Will rerun code in body to rebuild the object whenever a reactive value in the code changes.

Save the results to **output$<outputId>**

PREVENT REACTIONS

```
library(shiny)
ui <- fluidPage(
 textInput("a","","A"),
 textOutput("b")
)

server <-
function(input,output){
 output$b <-
  renderText({
   isolate({input$a})
  })
}

shinyApp(ui, server)
```

isolate(expr**)**

Runs a code block. Returns a **non-reactive** copy of the results.

TRIGGER ARBITRARY CODE

```
library(shiny)
ui <- fluidPage(
 textInput("a","","A"),
 actionButton("go","Go")
)

server <-
function(input,output){
 observeEvent(input$go,{
  print(input$a)
 })
}

shinyApp(ui, server)
```

observeEvent(eventExpr, **handlerExpr**, event.env, event.quoted, handler.env, handler.quoted, labe, suspended, priority, domain, autoDestroy, ignoreNULL**)**

Runs code in 2nd argument when reactive values in 1st argument change. See **observe()** for alternative.

MODULARIZE REACTIONS

```
ui <- fluidPage(
 textInput("a","","A"),
 textInput("z","","Z"),
 textOutput("b"))

server <-
function(input,output){
 re <- reactive({
paste(input$a,input$z)})
 output$b <- renderText({
  re()
 })
}
shinyApp(ui, server)
```

reactive(x, env, quoted, label, domain**)**

Creates a **reactive expression** that

- **caches** its value to reduce computation
- can be called by other code
- notifies its dependencies when it ha been invalidated

Call the expression with function syntax, e.g. `re()`

DELAY REACTIONS

```
library(shiny)
ui <- fluidPage(
 textInput("a","","A"),
 actionButton("go","Go"),
 textOutput("b")
)

server <-
function(input,output){
 re <- eventReactive(
  input$go,{input$a})
 output$b <- renderText({
  re()
 })
}

shinyApp(ui, server)
```

eventReactive(eventExpr, valueExpr, event.env, event.quoted, value.env, value.quoted, label, domain, ignoreNULL**)**

Creates reactive expression with code in 2nd argument that only invalidates when reactive values in 1st argument change.

UI - An app's UI is an HTML document.

Use Shiny's functions to assemble this HTML with R.

```
fluidPage(
  textInput("a","")
)
## <div class="container-fluid">
##  <div class="form-group shiny-input-container">
##    <label for="a"></label>
##    <input id="a" type="text"
##       class="form-control" value=""/>
##  </div>
## </div>
```

Returns HTML

Add static HTML elements with **tags**, a list of functions that parallel common HTML tags, e.g. **tags$a()**. Unnamed arguments will be passed into the tag; named arguments will become tag attributes.

tags$a	tags$data	tags$h6	tags$nav	tags$span
tags$abbr	tags$datalist	tags$head	tags$noscript	tags$strong
tags$address	tags$dd	tags$header	tags$object	tags$style
tags$area	tags$del	tags$hgroup	tags$ol	tags$sub
tags$article	tags$details	tags$hr	tags$optgroup	tags$summary
tags$aside	tags$dfn	tags$HTML	tags$option	tags$sup
tags$audio	tags$div	tags$i	tags$output	tags$table
tags$b	tags$dl	tags$iframe	tags$p	tags$tbody
tags$base	tags$dt	tags$img	tags$param	tags$td
tags$bdi	tags$em	tags$input	tags$pre	tags$textarea
tags$bdo	tags$embed	tags$ins	tags$progress	tags$tfoot
tags$blockquote	tags$eventsource	tags$kbd	tags$q	tags$th
tags$body	tags$fieldset	tags$keygen	tags$ruby	tags$thead
tags$br	tags$figcaption	tags$label	tags$rp	tags$time
tags$button	tags$figure	tags$legend	tags$rt	tags$title
tags$canvas	tags$footer	tags$li	tags$s	tags$tr
tags$caption	tags$form	tags$link	tags$samp	tags$track
tags$cite	tags$h1	tags$mark	tags$script	tags$u
tags$code	tags$h2	tags$map	tags$section	tags$ul
tags$col	tags$h3	tags$menu	tags$select	tags$var
tags$colgroup	tags$h4	tags$meta	tags$small	tags$video
tags$command	tags$h5	tags$meter	tags$source	tags$wbr

The most common tags have wrapper functions. You do not need to prefix their names with **tags$**

```
ui <- fluidPage(
  h1("Header 1"),
  hr(),
  br(),
  p(strong("bold")),
  p(em("italic")),
  p(code("code")),
  a(href="", "link"),
  HTML("<p>Raw html</p>")
)
```

Header 1

bold

italic

`code`

link

Raw html

To include a CSS file, use **includeCSS()**, or
1. Place the file in the **www** subdirectory
2. Link to it with

```
tags$head(tags$link(rel = "stylesheet",
  type = "text/css", href = "<file name>"))
```

To include JavaScript, use **includeScript()** or
1. Place the file in the **www** subdirectory
2. Link to it with

```
tags$head(tags$script(src = "<file name>"))
```

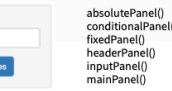
IMAGES

To include an image
1. Place the file in the **www** subdirectory
2. Link to it with `img(src="<file name>")`

Layouts

Combine multiple elements into a "single element" that has its own properties with a panel function, e.g.

```
wellPanel(dateInput("a", ""),
          submitButton()
)
```

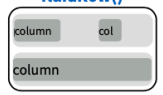


absolutePanel() conditionalPanel() fixedPanel() headerPanel() inputPanel() mainPanel()

navlistPanel() sidebarPanel() tabPanel() tabsetPanel() titlePanel() wellPanel()

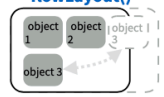
Organize panels and elements into a layout with a layout function. Add elements as arguments of the layout functions.

fluidRow()



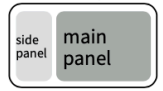

```
ui <- fluidPage(
 fluidRow(column(width = 4),
   column(width = 2, offset = 3)),
 fluidRow(column(width = 12))
)
```

flowLayout()



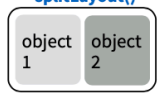

```
ui <- fluidPage(
 flowLayout( # object 1,
             # object 2,
             # object 3
 )
)
```

sidebarLayout()



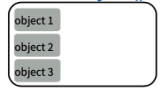

```
ui <- fluidPage(
 sidebarLayout(
  sidebarPanel(),
  mainPanel()
 )
)
```

splitLayout()




```
ui <- fluidPage(
 splitLayout( # object 1,
              # object 2
 )
)
```

verticalLayout()




```
ui <- fluidPage(
 verticalLayout( # object 1,
                 # object 2,
                 # object 3
 )
)
```

Layer tabPanels on top of each other, and navigate between them, with:

```
ui <- fluidPage( tabsetPanel(
  tabPanel("tab 1", "contents"),
  tabPanel("tab 2", "contents"),
  tabPanel("tab 3", "contents")))
```

```
ui <- fluidPage( navlistPanel(
  tabPanel("tab 1", "contents"),
  tabPanel("tab 2", "contents"),
  tabPanel("tab 3", "contents")))
```

```
ui <- navbarPage(title = "Page",
  tabPanel("tab 1", "contents"),
  tabPanel("tab 2", "contents"),
  tabPanel("tab 3", "contents"))
```

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Other visualizations

- In R:
  - https://www.htmlwidgets.org/showcase_plotly.html
  - https://www.r-graph-gallery.com/
  - https://rstudio.com/resources/cheatsheets/
  - https://ggplot2-book.org/
  - https://rkabacoff.github.io/datavis/
  - https://worldbank.github.io/r-econ-visual-library/index.html

- Other than R:
  - Tableau
  - Power BI
  - Python

More resources

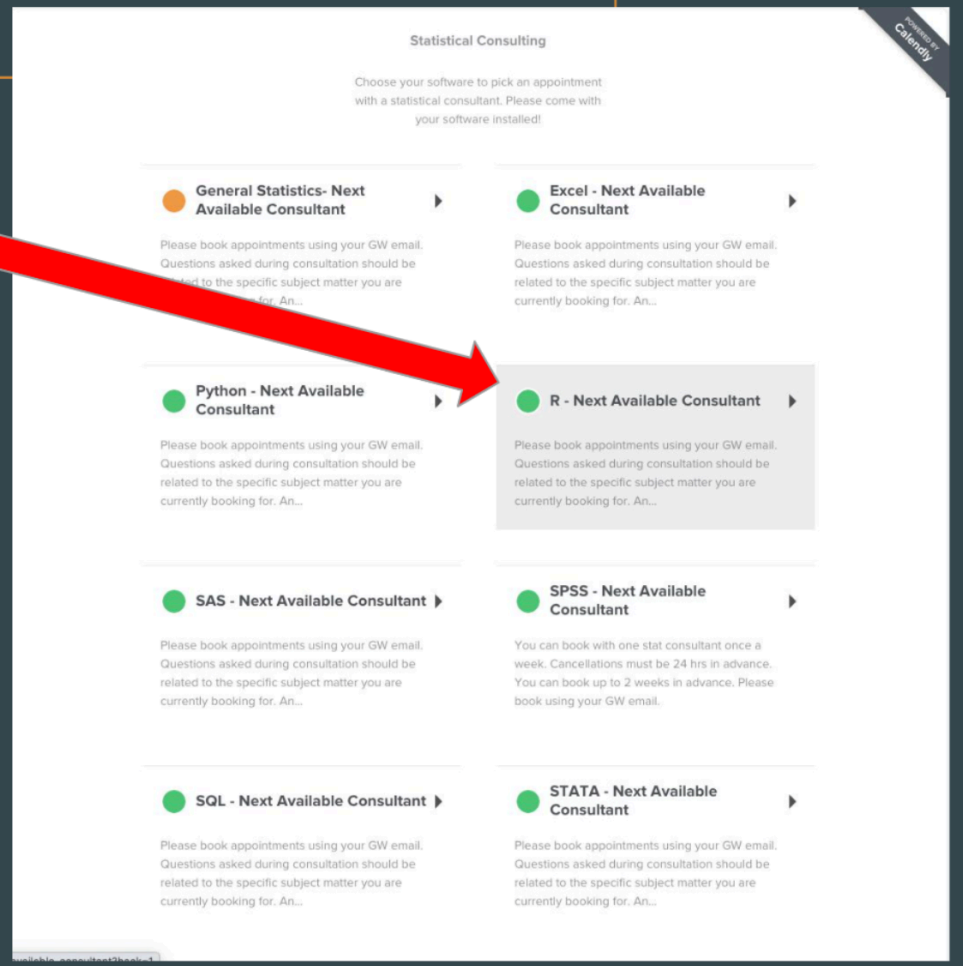
Statistics+R help @ GW

R-Statistics Appointments:
calendly.com/statistical-consulting-gw

Also...

Appointments with me:
calendly.com/kerchner

Coding consultations (Python, git, etc.):
calendly.com/gwul-coding/



Thanks!

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