Notes 4 - R Shiny

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Math 3190

What is Shiny?

`Shiny` is an **R** package that allows you to (relatively) easily create rich, interactive web apps around your **R** functions and packages. `Shiny` allows you to take your work in **R** and disseminate it via a web browser so that anyone can use it. `Shiny` makes you look awesome by making it easy to produce polished web apps with a minimum amount of pain.

(Credit: Some of the images and slide text were taken and adapted from https://mastering-shiny.org and RStudio's `Shiny` tutorials)

What is Shiny?

`Shiny` is designed primarily with data scientists in mind, and to that end, you can create pretty complicated `Shiny` apps with no knowledge of HTML, CSS, or JavaScript. On the other hand, `Shiny` doesn't limit you to creating trivial or prefabricated apps: its user interface components can be easily customized or extended, and its server uses reactive programming to let you create any type of back end logic you want.

What is Shiny?

Some of the things people use `Shiny` for are:

- Create dashboards
- Replace hundreds of pages of PDFs with interactive apps
- Communicate complex models informative visualizations
- Provide self-service data analysis for common workflows
- Create interactive demos for teaching statistics and data science

In short, `Shiny` gives you the ability to pass on some of your **R** superpowers to anyone who can use the web.

Getting Started

To create your first `Shiny` App you will need:

- **R** installed (of course).
- **RStudio** installed. (strongly recommended): https://www.rstudio.com/products/rstudio/download
- The **R** `Shiny` package: `install.packages("shiny")`
- Knowledge and experience in developing **R** packages (recommended).
- Git and GitHub (recommended): to share your Apps.

Getting Started

If you haven't already installed `Shiny`, install it with:

```
install.packages("shiny")
```

If you've already installed `Shiny`, use the following to check that you have version 1.5.0 or greater:

```
packageVersion("shiny")
```

```
## [1] '1.8.0'
```

RStudio's Shiny Showcase is an exciting assembly of exciting apps!

Or we can start with a very simple example

```
library(shiny)
runExample("01_hello")
```

Introduction to Shiny Development

Here we'll create a simple `Shiny` app, staring with the minimum boilerplate, followed by the two key components of every `Shiny` app: the UI (short for user interface) which defines how your app looks, and the server function which defines how your app works. `Shiny` uses **reactive** programming to automatically update outputs when inputs change.

Template: Shortest Viable App

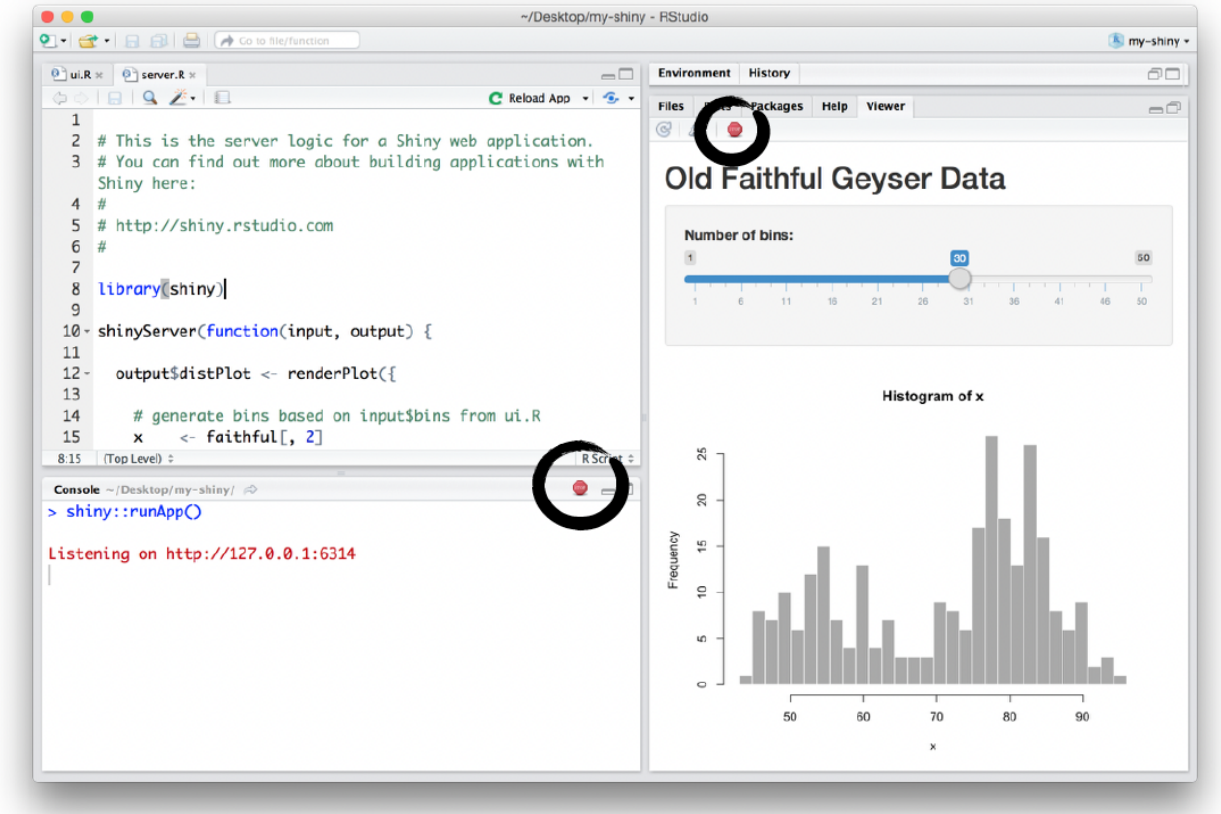
The simplest way to start an app is to create a new **R** script and start with the following code:

```
library(shiny)

ui <- fluidPage()

server <- function(input, output) {}

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

Close your App

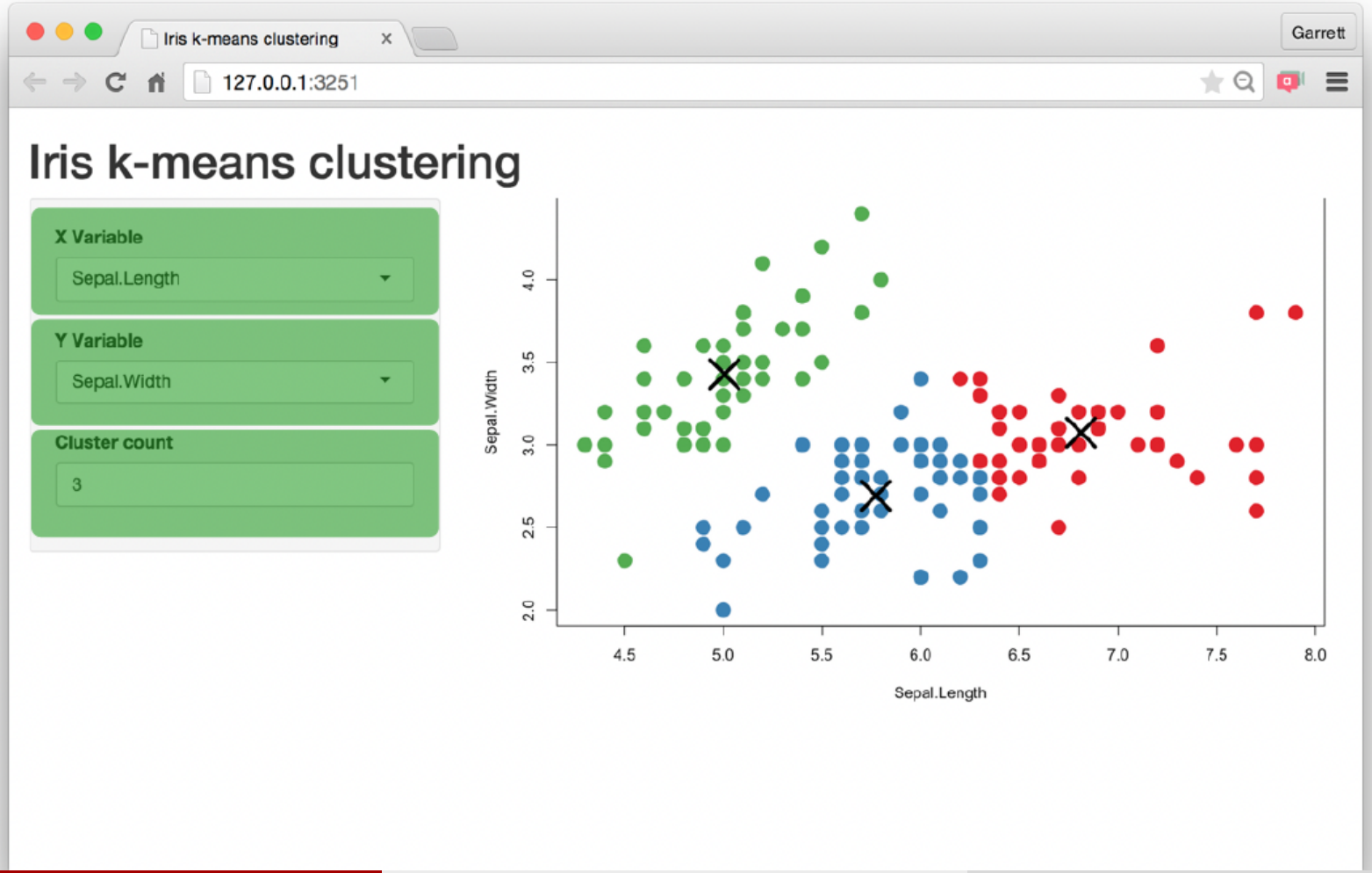
To close the Shiny app, press the stop button, close the window, or press escape from the console.

Close an app



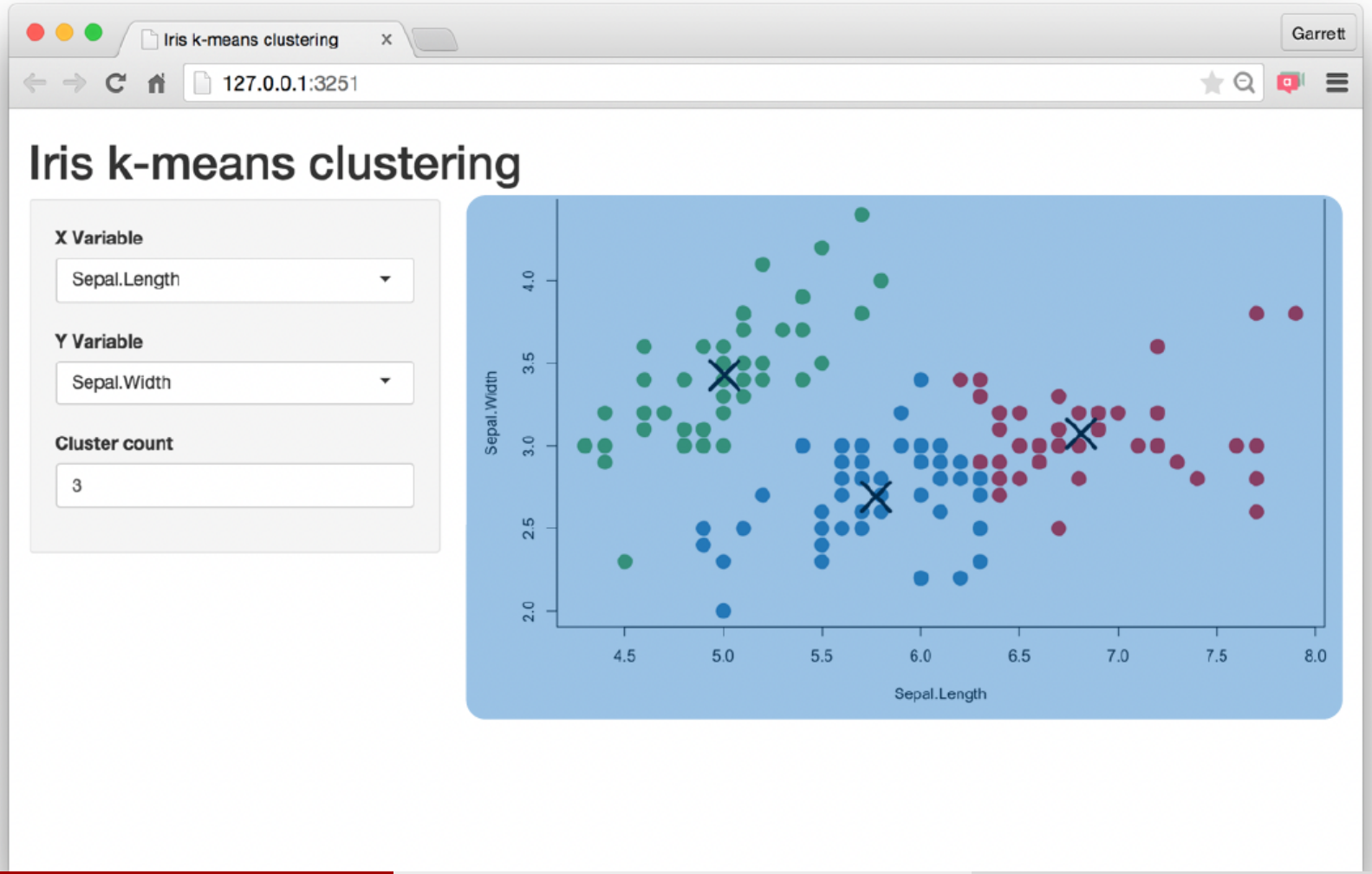
Inputs and Outputs

Build your app around **inputs** and **outputs**



Inputs and outputs

Build your app around **inputs** and **outputs**



Adding Elements to the UI

Add elements to your app as arguments to fluidPage()

```
library(shiny)

ui <- fluidPage(
    # Input() functions,
    # Output() functions
    )

server <- function(input, output) {}

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

Take note that the `ui` (or `fluidPage()` function in this case) is what controls what the app looks like and takes inputs from the user. The `server` function controls what the app is doing. `fluidPage()` is not the only function that can be used for the UI, but it is a good place to start.

Adding Elements to the UI

Add elements to your app as arguments to `fluidPage()`

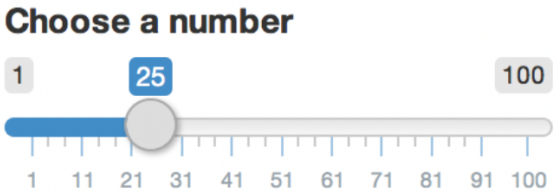
```
library(shiny)

ui <- fluidPage(
  "Hello World!"
  )

server <- function(input, output) {}

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

Input Functions

Create an input with a function that ends in **Input()**.

```
sliderInput(inputId = "num",
            label = "Choose a number",
            value = 25, min = 1, max = 100)
```

Syntax




```
sliderInput(inputId = "num", label = "Choose a number", …)
```

- input name (for internal use)
- Notice: Id not ID
- label to display
- input specific arguments

?sliderInput

Input Functions in an App

```
library(shiny)

ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100)
  )

server <- function(input, output) {}

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

The ID of in the `Input()` function, `inputId` in this case, creates an attribute of `input` that can be used in the `server` function inside of a `render()` function.

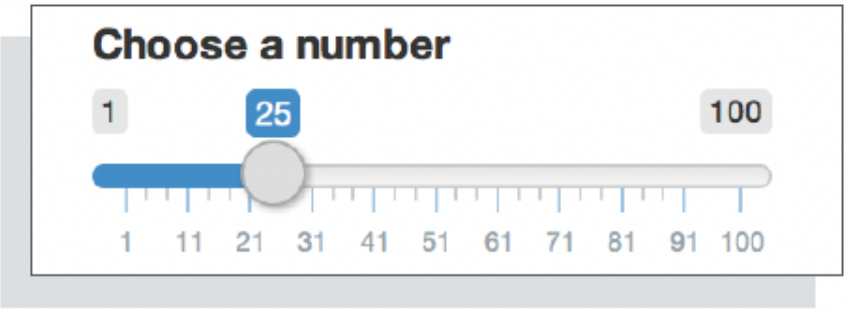
Server inputs

You can access inputs from the UI using **input$**

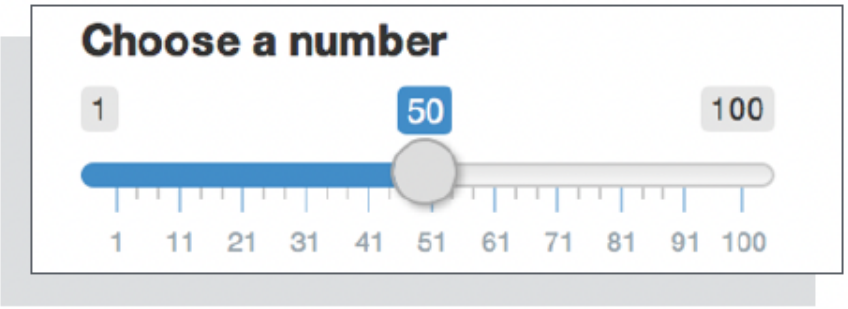
```
sliderInput(inputId = "num",...)
```

```
input$num
```

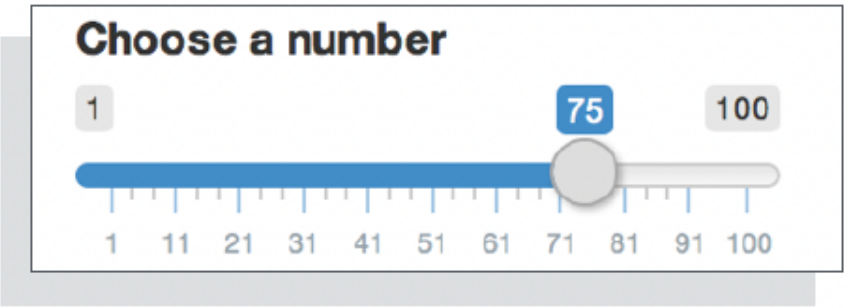
The input value changes whenever a user changes the input.




```
input$num = 25
```




```
input$num = 50
```




```
input$num = 75
```

Render Functions in an App

A `render...()` function (that is, a function that begins with the word "render") is used in the `server` function to create an attribute of `output`.

You can save your outputs to return to the UI using **output$** and build objects to display with a function whose name begins with `render`.

```
server <- function(input, output) {
  output$hist <- renderPlot({


  })
}
```

Render Functions in an App

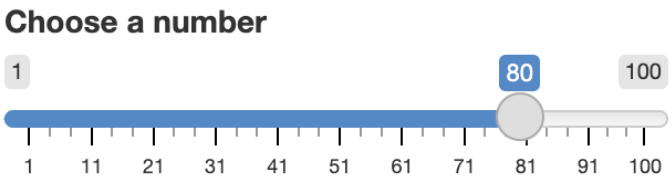
```
ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100)
  )

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

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

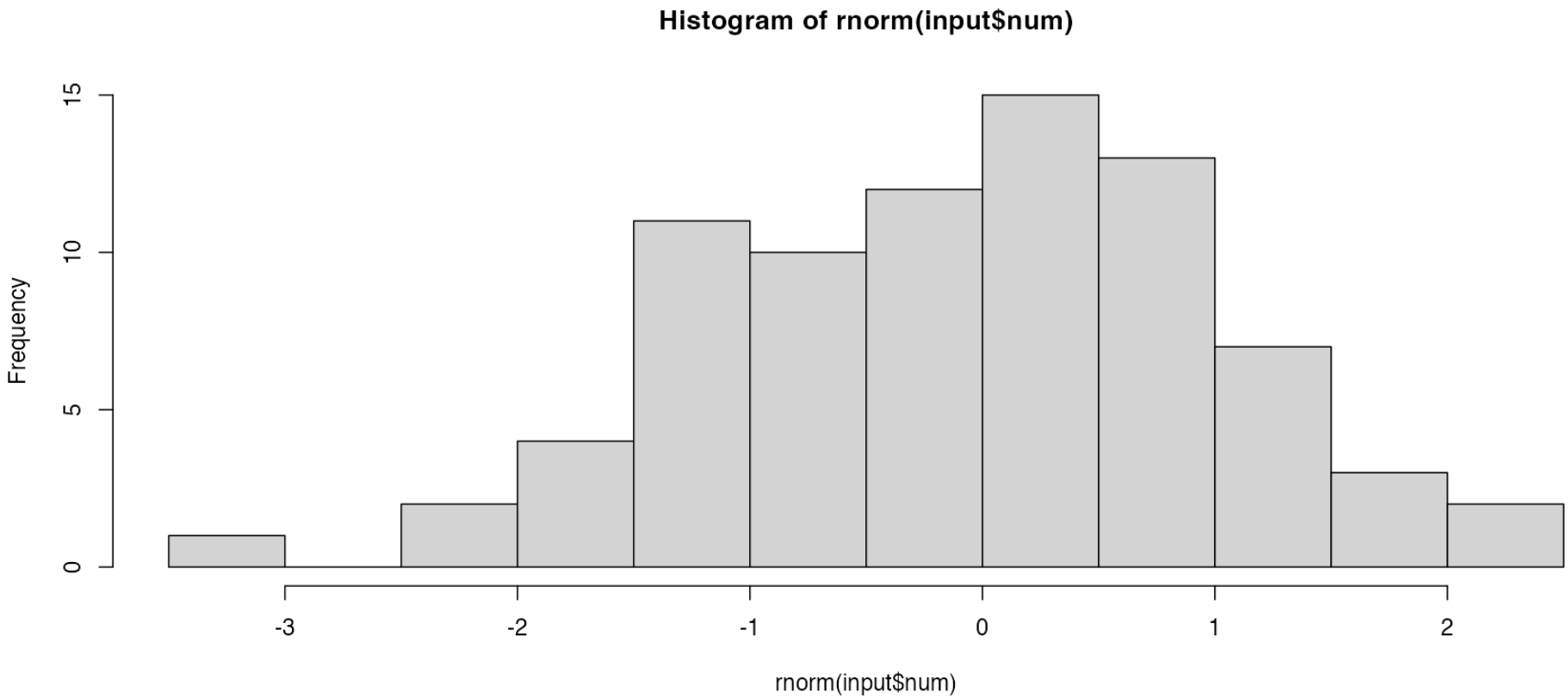
Output Functions in an App

Now that an attribute of `output` has been created, we need a `...Output()` function (a function that ends with the word "Output") inside `fluidPage()` in the `ui`. The name of the output attribute created in the `server` function must go in quotes.

```
ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100), # Comma!
  plotOutput("hist")
  )
server <- function(input, output) {
  output$hist <- renderPlot({
    hist(rnorm(input$num))
    })
}
shinyApp(server = server, ui = ui)
```

Shiny App


Choose a number
1
80
100
1
11
21
31
41
51
61
71
81
91
100

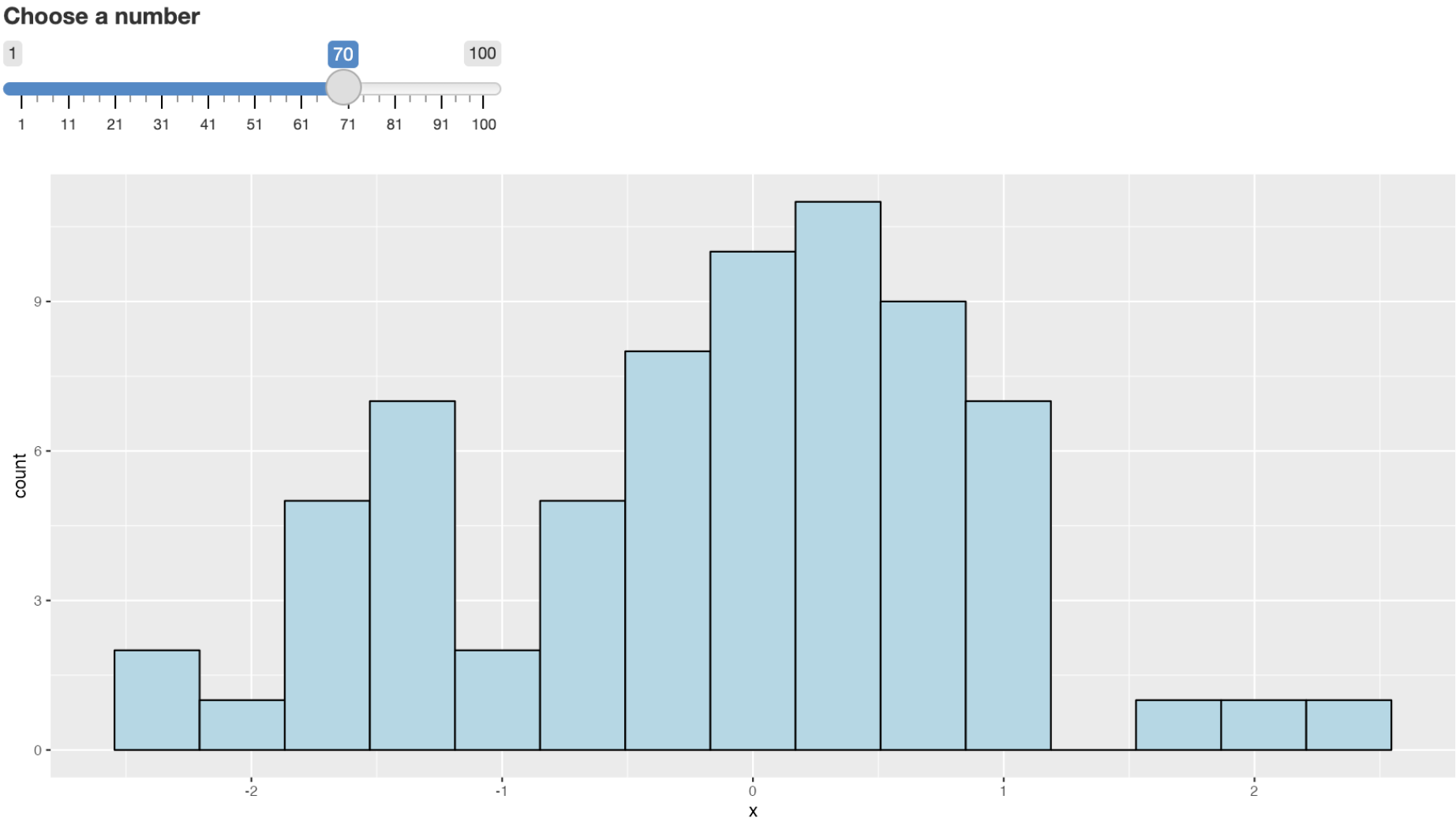

Histogram of rnorm(input$num)
Frequency
0
5
10
15
-3
-2
-1
0
1
2
rnorm(input$num)

Output Functions in an App

We can also make the graph look nicer with ggplot.

```
library(tidyverse)
ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100), # Comma!
  plotOutput("hist")
  )
server <- function(input, output) {
  output$hist <- renderPlot({
    DF <- data.frame(x = rnorm(input$num))
    ggplot(DF, aes(x = x)) +
      geom_histogram(color = "black", fill = "lightblue",
                     bins = 15)
    })
}
shinyApp(server = server, ui = ui)
```

Shiny App


Choose a number
1
70
100
1
11
21
31
41
51
61
71
81
91
100
count
9
6
3
0
-2
-1
0
1
2
x

Shiny Buttons (Inputs)

Buttons

Action

Submit

`actionButton()`
`submitButton()`

Single checkbox

Choice A

`checkboxInput()`

Checkbox group

Choice 1
Choice 2
Choice 3

`checkboxGroupInput()`

Date input

2014-01-01

`dateInput()`

Date range

2014-01-24 to 2014-01-24

`dateRangeInput()`

File input

Choose File No file chosen

`fileInput()`

Numeric input

1

`numericInput()`

Password Input

`passwordInput()`

Radio buttons

Choice 1
Choice 2
Choice 3

`radioButtons()`

Select box

Choice 1

`selectInput()`

Sliders

0 50 100

0 25 75 100

`sliderInput()`

Text input

Enter text...

`textInput()`

Shiny Renders

Use the **render*()** function that creates the type of output you wish to make.

function	creates
`renderDataTable()`	An interactive table (from a data frame, matrix, or other table-like structure)
`renderImage()`	An image (saved as a link to a source file)
`renderPlot()`	A plot
`renderPrint()`	A code block of printed output
`renderTable()`	A table (from a data frame, matrix, or other table-like structure)
`renderText()`	A character string
`renderUI()`	a Shiny UI element

Shiny Outputs

Function	Inserts
`dataTableOutput()`	an interactive table
`htmlOutput()`	raw HTML
`imageOutput()`	image
`plotOutput()`	plot
`tableOutput()`	table
`textOutput()`	text
`uiOutput()`	a Shiny UI element
`verbatimTextOutput()`	text

Interactive Plots with `plotly`

A package that pairs very nicely with Shiny is the `plotly` package. This package allows us to create interactive plots with hover features. Some esspecially nice functions in `plotly` are:

- `ggplotly()`: This takes a ggplot object and coverts it to a plotly object to make it interactive.
- `renderPlotly()`: This can be put in the `server` function to render an interactive plot that can be saved to an output.
- `plotlyOutput()`: This can be put in the `fluidPage()` function to generate an interactive plot in the Shiny app.

Interactive Plots with plotly

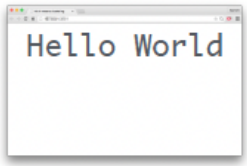
Taking the plot from the last output and making it interactive:

```
library(shiny); library(tidyverse); library(plotly)
ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100), # Comma!
  plotlyOutput("hist") # Note: changed from plotOutput to plotlyOutput
  )
server <- function(input, output) {
  output$hist <- renderPlotly({ # Note: changed to renderPlotly
    DF <- data.frame(x = rnorm(input$num))
    p <- ggplot(DF, aes(x = x)) + # Save object as p
      geom_histogram(color = "black", fill = "lightblue",
                     bins = 15)
    ggplotly(p) # Make the ggplot interactive
    })
}
shinyApp(server = server, ui = ui)
```

Recap

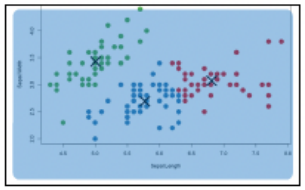
```
library(shiny)
ui <- fluidPage()
server <- function(input, output) {}
shinyApp(ui = ui, server = server)
```

Begin each app with the template

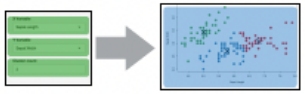


Add elements as arguments to **fluidPage()**

Create reactive inputs with an ***Input()** function



Display reactive results with an ***Output()** function



Assemble outputs from inputs in the server function

Recap: Server

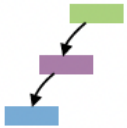
Use the server function to assemble inputs into outputs. Follow 3 rules:

`output$hist <-` 1. Save the output that you build to **output$**

```
renderPlot({
  hist(rnorm(input$num))
})
```

2. Build the output with a **render*()** function

`input$num` 3. Access input values with **input$**



Create reactivity by using **Inputs** to build **rendered Outputs**

Building the Server

There are 2 basic rules for your **fluidPage()** function:

1. Save input values with one of the Shiny buttons. Most of these functions end with `Input()` or `Button()`.
2. Use a function that ends with `output()` in `fluidPage()` to display objects built with a render...()** function in the server.

There are 3 basic rules for your **server** function:

1. Save objects to display as `output$`.
2. Build objects to display with `render...()`.
3. Access input values with `input$`.

Reactivity

Shiny is built on reavtive objects. The term **reactivity** refers to the idea that the inputs and outputs are connected to each other: when you change and input, you change all outputs that require the input.

If we ever want to do anything with the input out of a `render...()` function, we need to use the `reactive()` function around it. Then, to use any variable defined with a `reactive()` function, we need to call it with parentheses. This is most common if you want to use that object in multiple `render...()` functions.

Reactivity

```
ui <- fluidPage(
  sliderInput(inputId = "num", label = "Choose a number",
    value = 25, min = 1, max = 100), # Comma!
  plotOutput("hist"),
  plotOutput("box")
  )
server <- function(input, output) {
  rand_DF <- reactive(data.frame(x = rnorm(input$num)))
  # rand_values <- input$num |> rnorm() |> reactive()
  output$hist <- renderPlot({
    ggplot(rand_DF(), aes(x = x)) +
      geom_histogram(color = "black", fill = "lightblue", bins = 15) +
      geom_vline(xintercept = median(rand_DF()$x), linewidth = 1) +
      coord_cartesian(xlim = c(-3, 3))
    })
  output$box <- renderPlot({
    ggplot(rand_DF(), aes(x = x)) +
      geom_boxplot(color = "black", fill = "lightblue") +
      coord_cartesian(xlim = c(-3, 3))
    })
}
shinyApp(server = server, ui = ui)
```

Without Reactivity

```
ui <- fluidPage(
  sliderInput(inputId = "num", label = "Choose a number",
    value = 25, min = 1, max = 100), # Comma!
  plotOutput("hist"),
  plotOutput("box")
  )
server <- function(input, output) {
  output$hist <- renderPlot({
    rand_DF <- data.frame(x = rnorm(input$num))
    ggplot(rand_DF, aes(x = x)) +
      geom_histogram(color = "black", fill = "lightblue", bins = 15) +
      geom_vline(xintercept = median(rand_DF$x), linewidth = 1) +
      coord_cartesian(xlim = c(-3, 3))
    })
  output$box <- renderPlot({
    rand_DF <- data.frame(x = rnorm(input$num))
    ggplot(rand_DF, aes(x = x)) +
      geom_boxplot(color = "black", fill = "lightblue") +
      coord_cartesian(xlim = c(-3, 3))
    })
} # In this case, different values are plotted in each plot!
shinyApp(server = server, ui = ui)
```

Multi-file apps:

When these Shiny apps get larger, it is common practice to create two files: a **ui.R** file and a **server.R** file.

```
#ui.R
library(shiny)
ui <- fluidPage(
  sliderInput(inputId = "num",
    label = "Choose a number",
    value = 25, min = 1, max = 100),
  plotOutput("hist")
  )
```

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

Multi-file apps:

And then finally the program file, **app.R**:

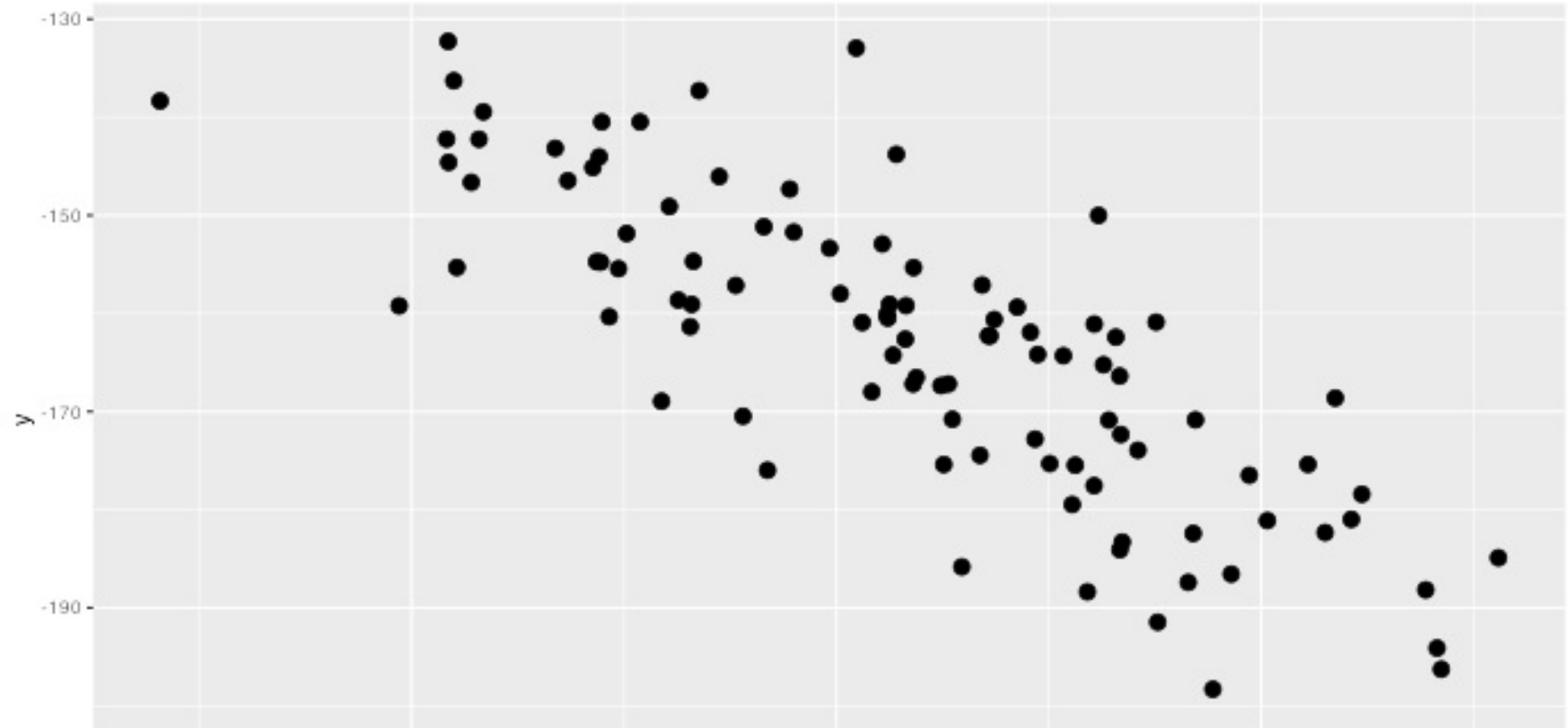
```
#app.R
library(shiny)

source("ui.R")
source("server.R")

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

Shiny Example

```
##
## Listening on http://127.0.0.1:3660
```

Guess the correlation!

Submit Guess



Hosting Shiny Apps

You can put your Shiny app in a GitHub repository and then run it (or have someone else run it) by using the `runGitHub()` function in the `shiny` library. The syntax is either of the following:

```
runGitHub("repository_name", "username")
runGitHub("username/repository_name")
```

By default, this will only work if your entire app is in a file called `app.R` with `shinyApp(ui = ui, server = server)` as the last line or if your app is split up into two files: `ui.R` and `server.R`.

If the Shiny app is in a different directory in your repository, you can specify what folder it is in by using the `subdir` option in the `runGitHub()` function:

```
runGitHub("repository_name", "username",
          subdir = "path/to/shiny/app/in/repo")
```

Building Apps in **R** Packages

We can also add a Shiny app to any **R** package we create. In the package directory, create an `inst/shiny/app_name` directory and place either the `app.R` file or the `ui.R` and `server.R` files in there. Once this is done, be sure to add "shiny" to the "Depends:" section of your `DESCRIPTION` file.

Then, in the package `R/` folder, add a function that calls the Shiny app. A template for this is on the next slide.

Also:

- Write the package functions first!
  - You can use any functions defined in your package in your shiny app.
- `Shiny` app should call functions, provide inputs, display results, etc.

You can check out the mypackage repo in my GitHub page for an example.

Building Apps in **R** Packages:

```r
#' Shiny App Name
#'
#' App description
#'
#' @export

# Change the name of the function to be relevant.
# It is convention to begin the name of this function with "run"
runShinyApp <- function() {
  appDir <- system.file("shiny", "app_name", package = "package_name")
  if (appDir == "") {
    stop("Could not find example directory. Try re-installing `package_name`.",
         call. = FALSE)
  }

  shiny::runApp(appDir, display.mode = "normal")
}
```

shinylive

It is also possible to run Shiny completely in a browser using WebR and shinylive. In fact, you can host Shiny apps on github. This is a beyond the scope of our class, but here are some links to some tutorials:

1. https://github.com/posit-dev/r-shinylive
2. https://medium.com/@rami.krispin/deploy-shiny-app-on-github-pages-b4cbd433bdc
3. https://hypebright.nl/index.php/en/2023/10/02/run-a-shiny-app-in-the-browser-with-shinylive-for-r/

An example of this is given at this link:
https://rbrown53.github.io/ShinyCorrelation/

Session info

```
sessionInfo()
```

```
## R version 4.3.2 (2023-10-31)
## Platform: aarch64-apple-darwin20 (64-bit)
## Running under: macOS Sonoma 14.2.1
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRlapack.dylib;  LAPACK version 3
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/Denver
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets
## [6] methods   base
##
## other attached packages:
##  [1] shiny_1.8.0     dslabs_0.7.6    lubridate_1.9.3
##  [4] forcats_1.0.0   stringr_1.5.1   dplyr_1.1.4
##  [7] purrr_1.0.2     readr_2.1.5     tidyr_1.3.1
## [10] tibble_3.2.1    ggplot2_3.4.4   tidyverse_2.0.0
##
## loaded via a namespace (and not attached):
##  [1] sass_0.4.8        utf8_1.2.4
##  [3] generics_0.1.3    stringi_1.8.3
##  [5] hms_1.1.3         digest_0.6.34
##  [7] magrittr_2.0.3    evaluate_0.23
##  [9] grid_4.3.2        timechange_0.3.0
## [11] fastmap_1.1.1     jsonlite_1.8.8
```