Lecture 4.Introduction to R Shinny

PUBH 6199: Visualizing Data with R, Summer 2025

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Outline for today

- **What is R Shinny**
- Write a basic R shiny app
- Deploy your Shiny apps with shinyapps.io
- AI-powered help: using Shiny Assistant

About R Shinny

- Shiny is an R package that makes it easy to build interactive web applications (apps) straight from R
- Shiny allows users to build dynamic, data-driven web apps without requiring extensive knowledge of web development
- To install **R Shinny** run the following command in the console of your RStudio

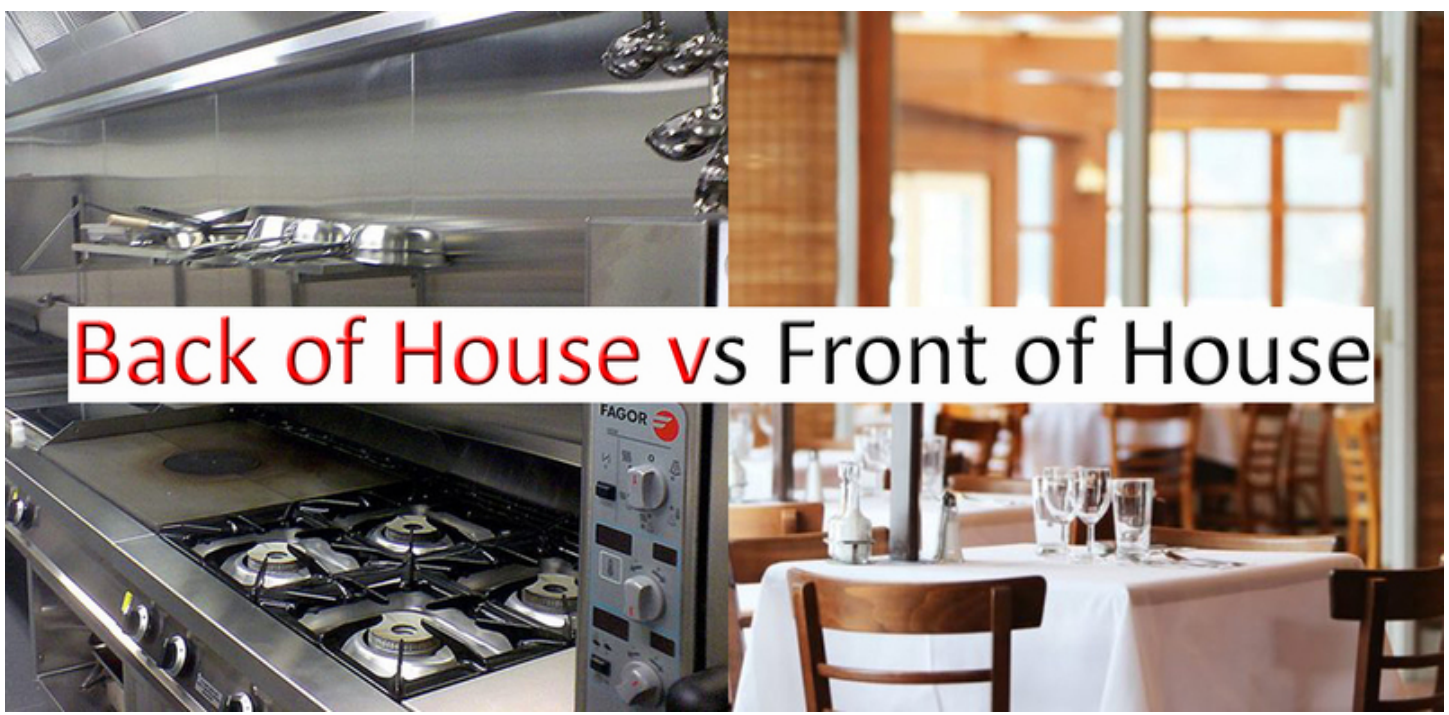
```
install.packages("shiny")
```

Key Features

- **Interactive Web Applications**: Shiny makes web apps that respond to user inputs
- **Seamless Integration with R**: Users can leverage the full power of R, like data manipulation, statistical modeling, and plotting
- **Easy Deployment** using Shiny Cloud
- **Extensibility**: Shiny apps can be enhanced with custom HTML, CSS, and JavaScript

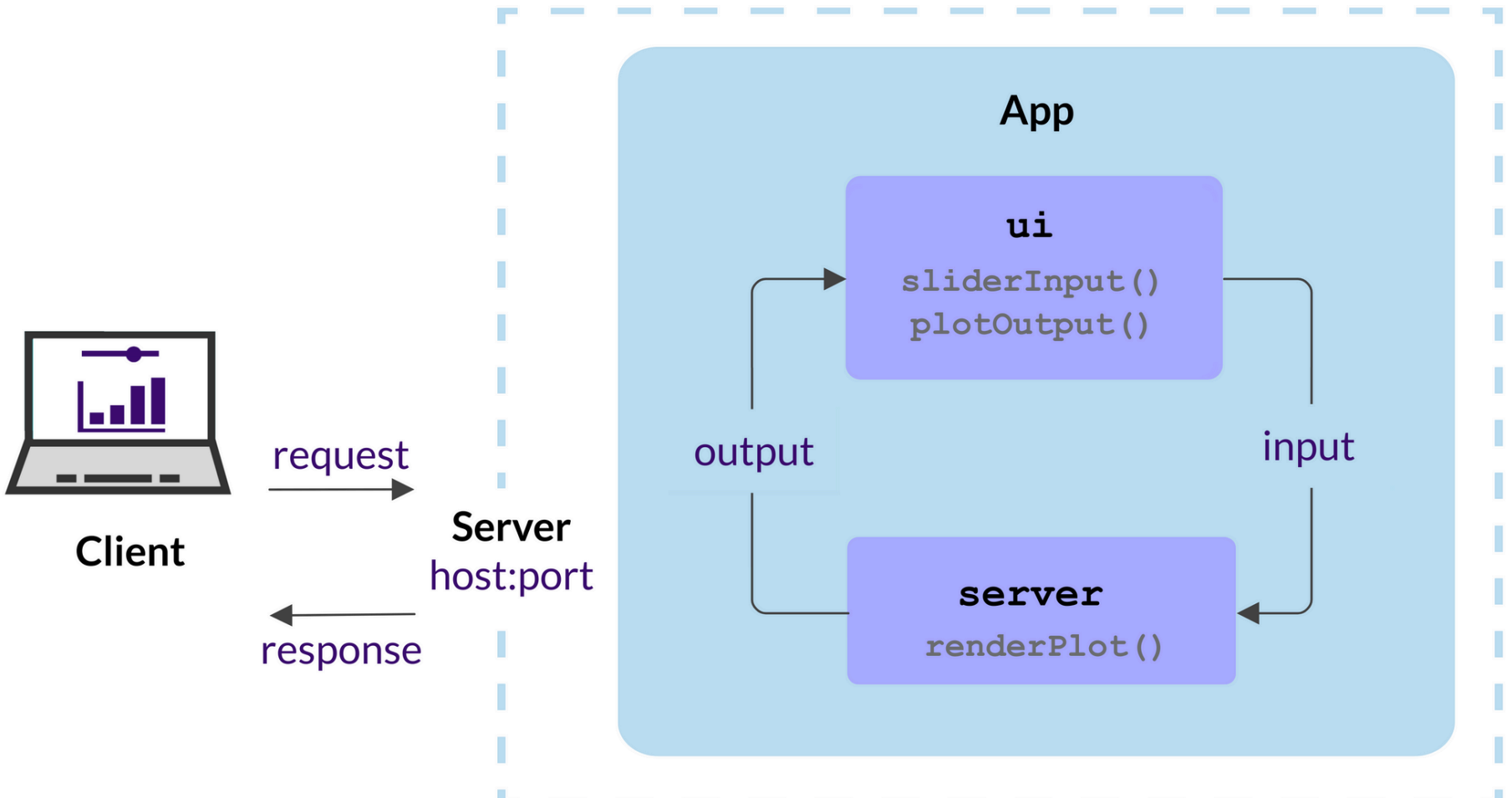
Basic Structure Shiny Application

- A typical Shiny application has two main components:
  - **User Interface (UI)**: Defines the layout and appearance of the app, including input controls (like sliders and text boxes) and output displays (like plots and tables).
  - **Server Function**: Contains the logic that processes inputs and generates outputs. It reacts to user interactions



Visual Logic

- Here we can see the visual logic behind a Shiny application



`*Input()`, `*Output()` and `render*()`

These three groups of functions are the core of Shiny's reactive programming model:

- **`*Input()`**: Represents user inputs, such as text input, slider input, or checkbox input. For example, `input$sliderValue` retrieves the value of a slider input with the ID "sliderValue".
- **`*Output()`**: Represents outputs that are displayed in the UI, such as plots, tables, or text. For example, `output$histPlot` refers to a plot output with the ID "histPlot".
- **`render*()`**: Functions that generate outputs based on inputs. For example, `renderPlot()` creates a plot output, and `renderText()` generates text output. These functions are reactive and will automatically update when the inputs change.

`*Input()` function syntax

Shiny input functions: `sliderInput()`, `selectInput()`, `textInput()` `numericInput()`, etc.

General format:

```
1 inputFunction(inputId, label, value, ...)
```

- `inputId`: connects UI and server via `input$inputId`, must be a simple string without spaces, must be unique within the app
- `label`: text label for the input control, displayed in the UI
- `value`: initial value of the input control, can be a number, character, or logical value. For example:

```
1 # use position for inputId and label
2 # use named args for the rest
3 sliderInput("min", "Limit (minimum)", value = 50, min = 0, max = 100)
```


Different types of UI Inputs

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)

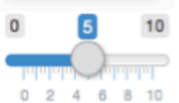
Choose File — **fileInput**(inputId, label, multiple, accept)

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())



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)

Source: Shiny for R cheatsheet

`*Output()` function syntax

Shiny output functions: `plotOutput()`, `tableOutput()`, `textOutput()`, etc.

What `*Output()` function does:

- Output functions in the **UI** create **placeholders**.
- These placeholders are **filled by the server** using a matching `render*()` function.

General format:

```
1 outputFunction(outputId)
```

- `outputId`: connects UI and server via `output$outputId`, must be a simple string without spaces, must be unique within the app. For example:

```
1 plotOutput("scatterplot")
```

- Accessed in server as:

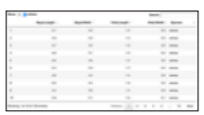
```
1 output$outputId <- renderFunction({...})
```


Output <-> Render pairing

```
# UI
plotOutput("my_plot")
# Server
output$my_plot <- renderPlot({
  ggplot(data, aes(...)) + geom_point()
})
```

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

works with

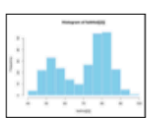


DT::renderDataTable(expr, options, callback, escape, env, quoted)

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)

foo

renderText(expr, env, quoted, func)

textOutput(outputId, container, inline)

renderUI(expr, env, quoted, func)

&

uiOutput(outputId, inline, container, …)

htmlOutput(outputId, inline, container, …)

Source: Shiny for R cheatsheet

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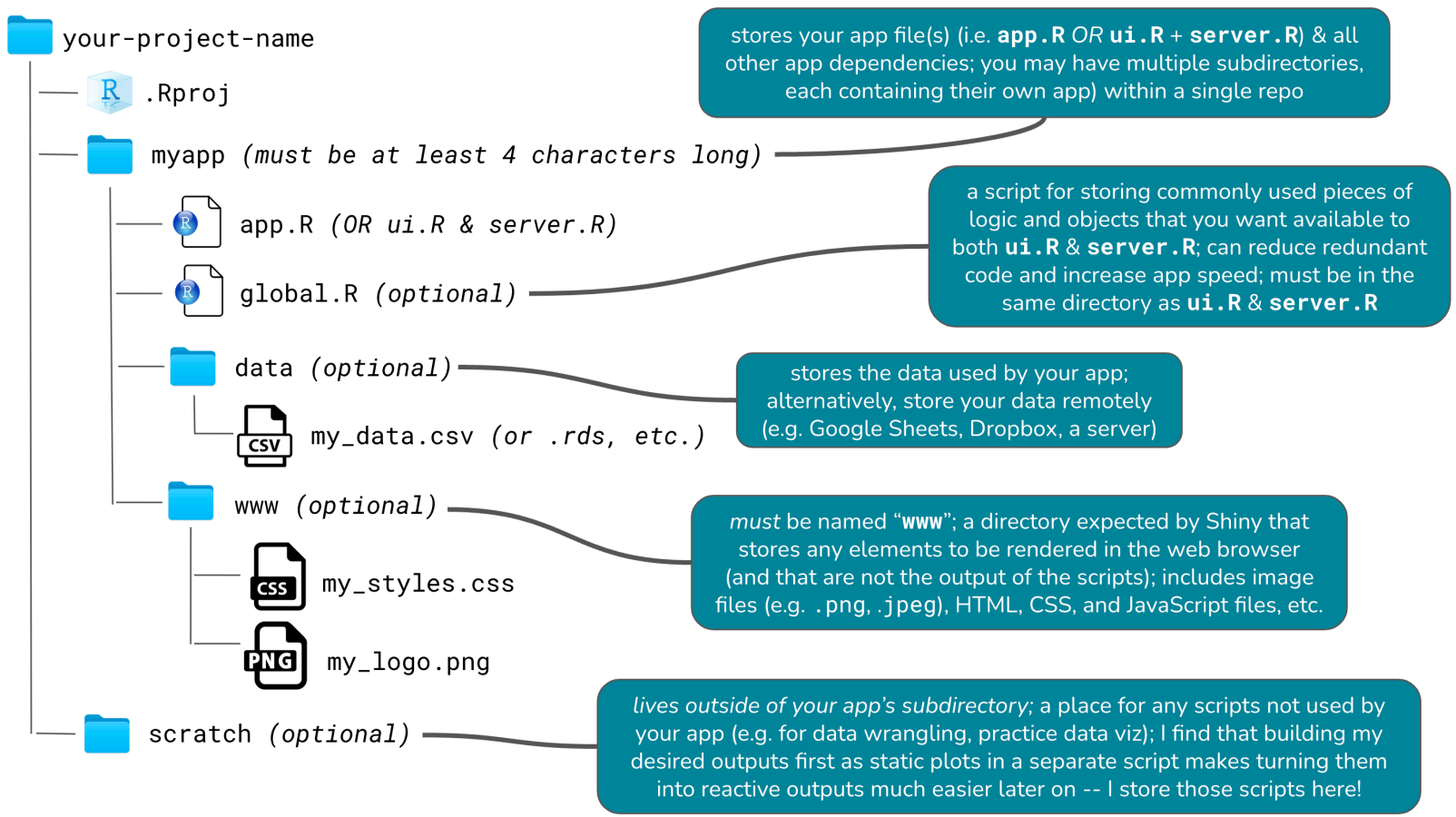
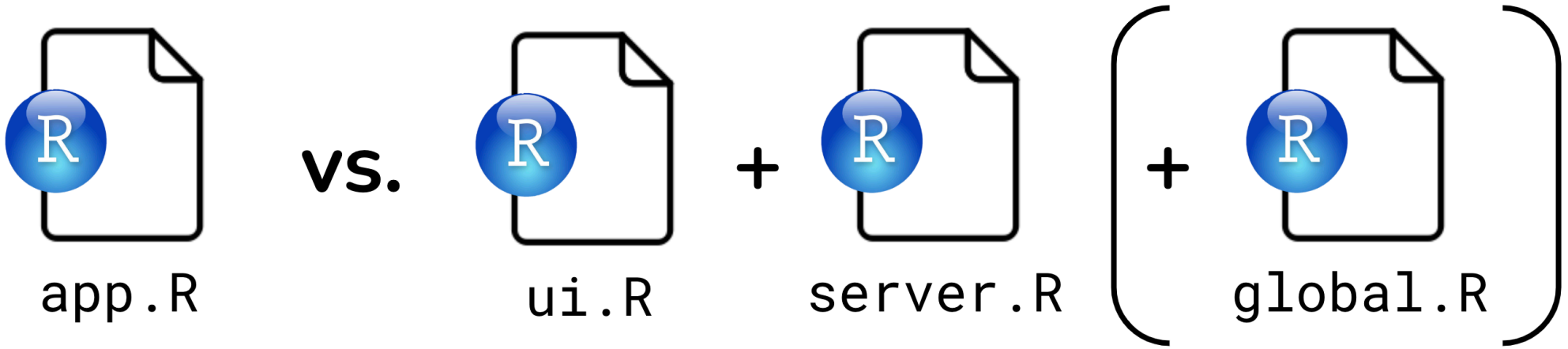
- What is R Shinny
- **Write a basic R shiny app**
- Deploy your Shiny apps with shinyapps.io
- AI-powered help: using Shiny Assistant

Setting up a shiny app

- Create a GitHub repo and clone the repo to our computer
- Install R Shiny in your R environment : `install.packages("shiny")`
- Organize repo structure



Two options for shiny apps



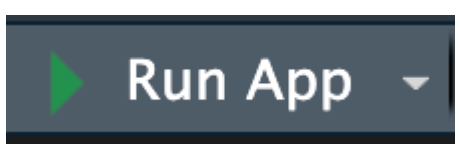
- **Single-File App**: All code is in one file, typically named `app.R`. This is suitable for simple applications or creating a reprex example.
- **Two-File App**: Code is split into multiple files, usually `ui.R` for the user interface and `server.R` for the server logic. Optionally, `global.R` can be used for data ingestion and wrangling. This is better for larger applications.

Create a single-file Shiny app

- Create a new R script file named `app.R`
- The file should contain both the UI and server components
- The basic structure of a single-file Shiny app is as follows:

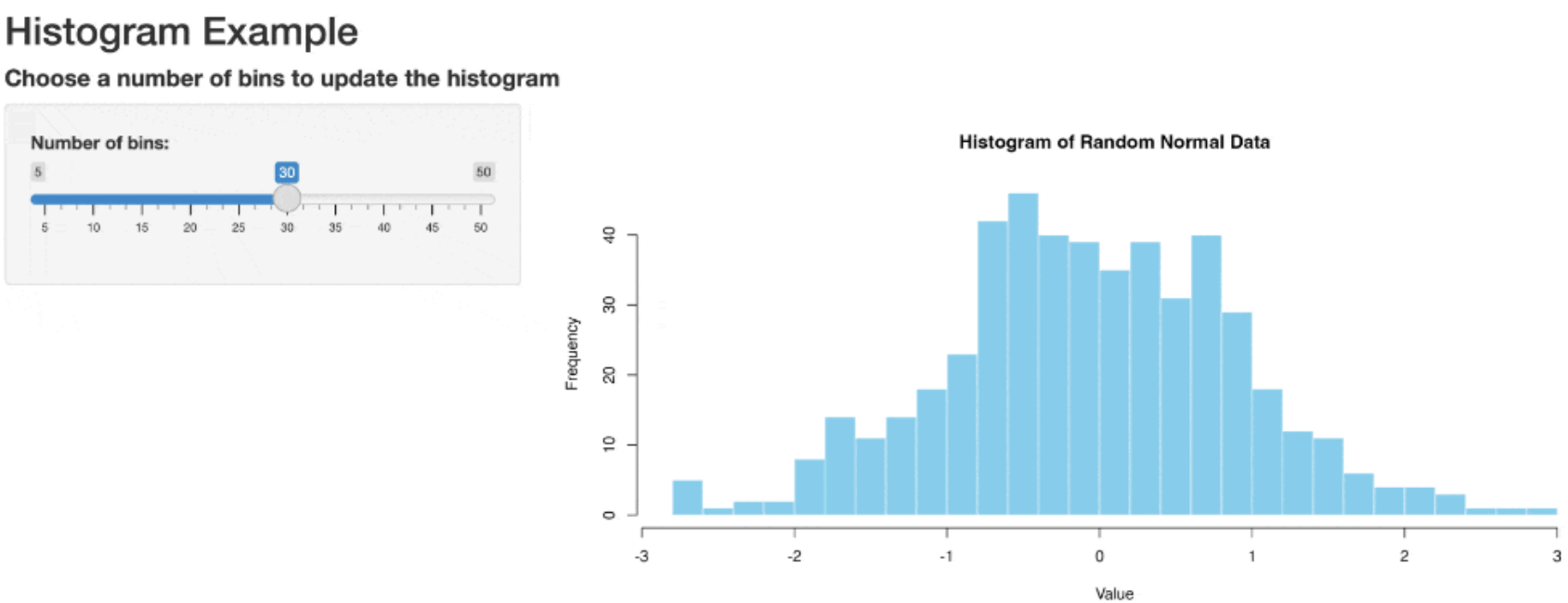
```
# load packages ----
library(shiny)

# user interface ----
ui <- fluidPage()

# server instructions ----
server <- function(input, output) {}

# combine UI & server into an app ----
shinyApp(ui = ui, server = server)
```

Once you have this structure, RStudio recognize this is a R shiny app and you can run the app by clicking the “Run App” button in RStudio.



Let’s build the app step-by-step

- We will create a simple Shiny app that displays a histogram of random normal data
- The app has a title and subtitle
- Users can adjust the number of bins in the histogram using a slider input
- The histogram will react to the slider input and update accordingly



Code Breakdown UI

Calling the library

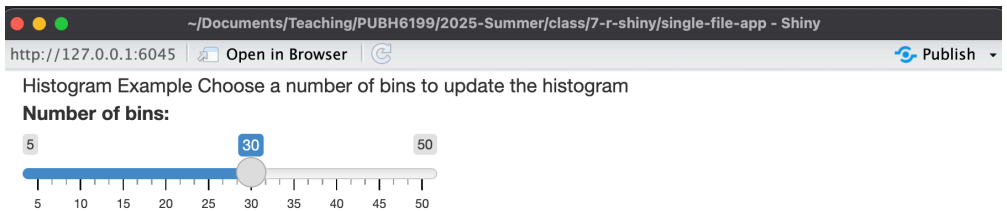
```
1 library(shiny)
```

Define the User Interface (UI) of the app, consisting of a title, a subtitle, a slider input, and a plot output

```
1  ui <- fluidPage(
2    # app title
3    "Histogram Example",
4    # app subtitle
5    "Choose a number of bins to update the histogram",
6    # slider input
7    sliderInput("bins",
8                "Number of bins:",
9                min = 5, max = 50, value = 30),
10   # histogram output
11   plotOutput("histPlot")
12 )
```

Click Run App, what do you see? what is different from what you imagined?

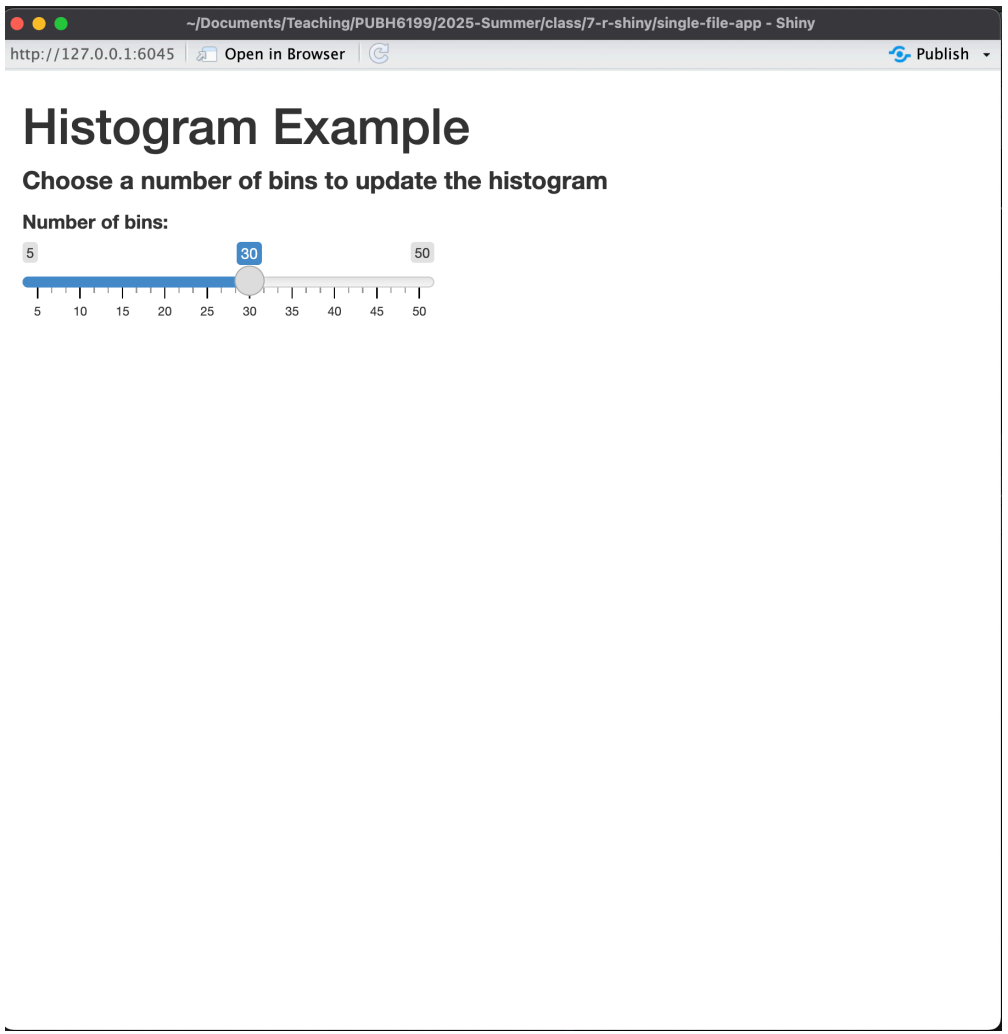
UI Work-in-Progress



1. There is no distinction between title and subtitle
2. There is no plot

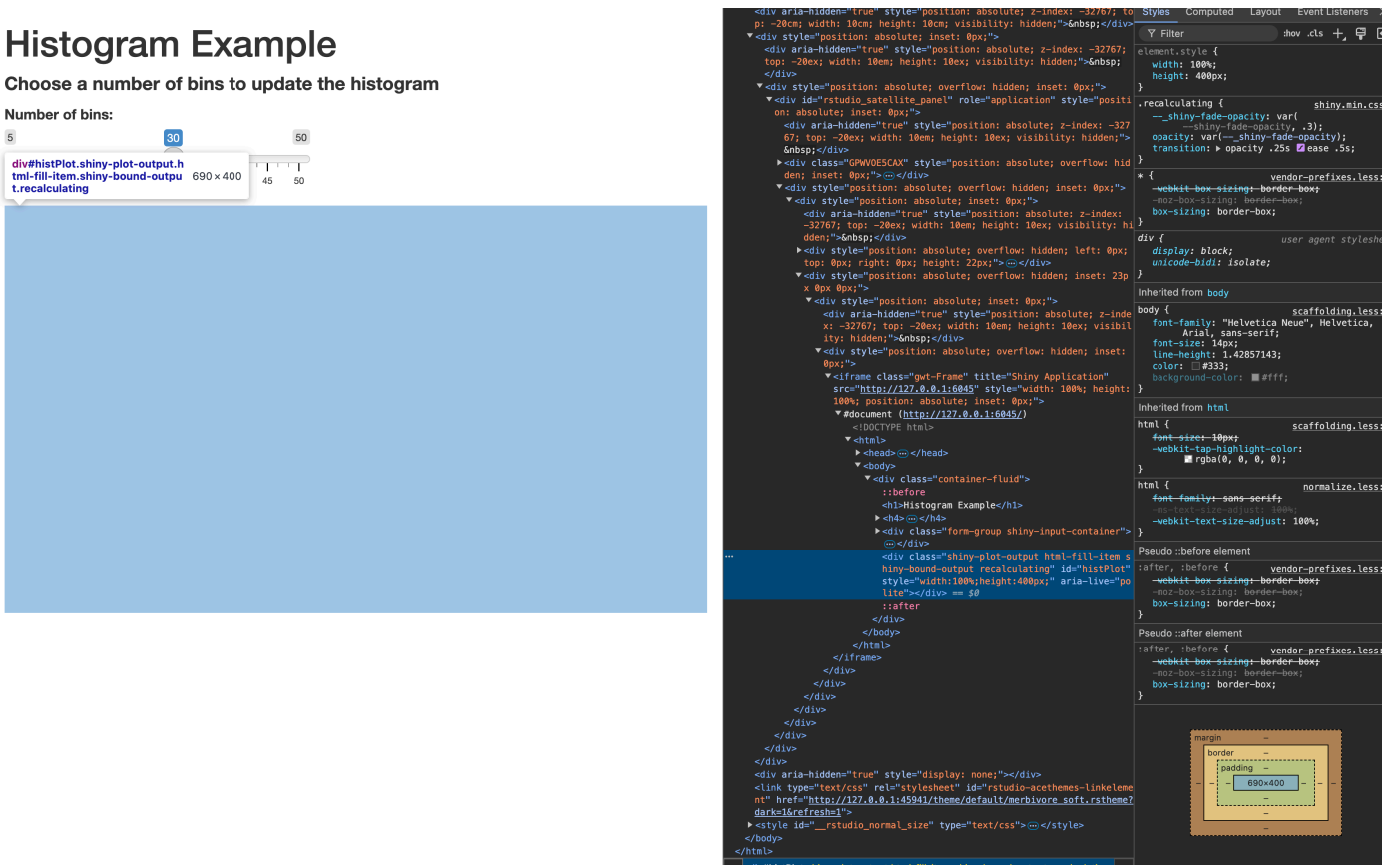
Adding hierarchy to the text

```
ui <- fluidPage(
  # app title
  h1("Histogram Example"),
  # app subtitle
  h4(strong("Choose a number of bins to update the h
  # slider input
  sliderInput("bins",
              "Number of bins:",
              min = 5, max = 50, value = 30),
  # histogram output
  plotOutput("histPlot")
)
```



Plot placeholder is present

When developing with R shiny, it is recommended that you use Google Chrome browser, and learn how to **inspect** html pages by right-clicking on the page and selecting “Inspect” or pressing `Ctrl + Shift + I` (Windows/Linux) or `Cmd + Option + I` (Mac).



But the plot is not there yet, we need to add the server logic to create the plot.

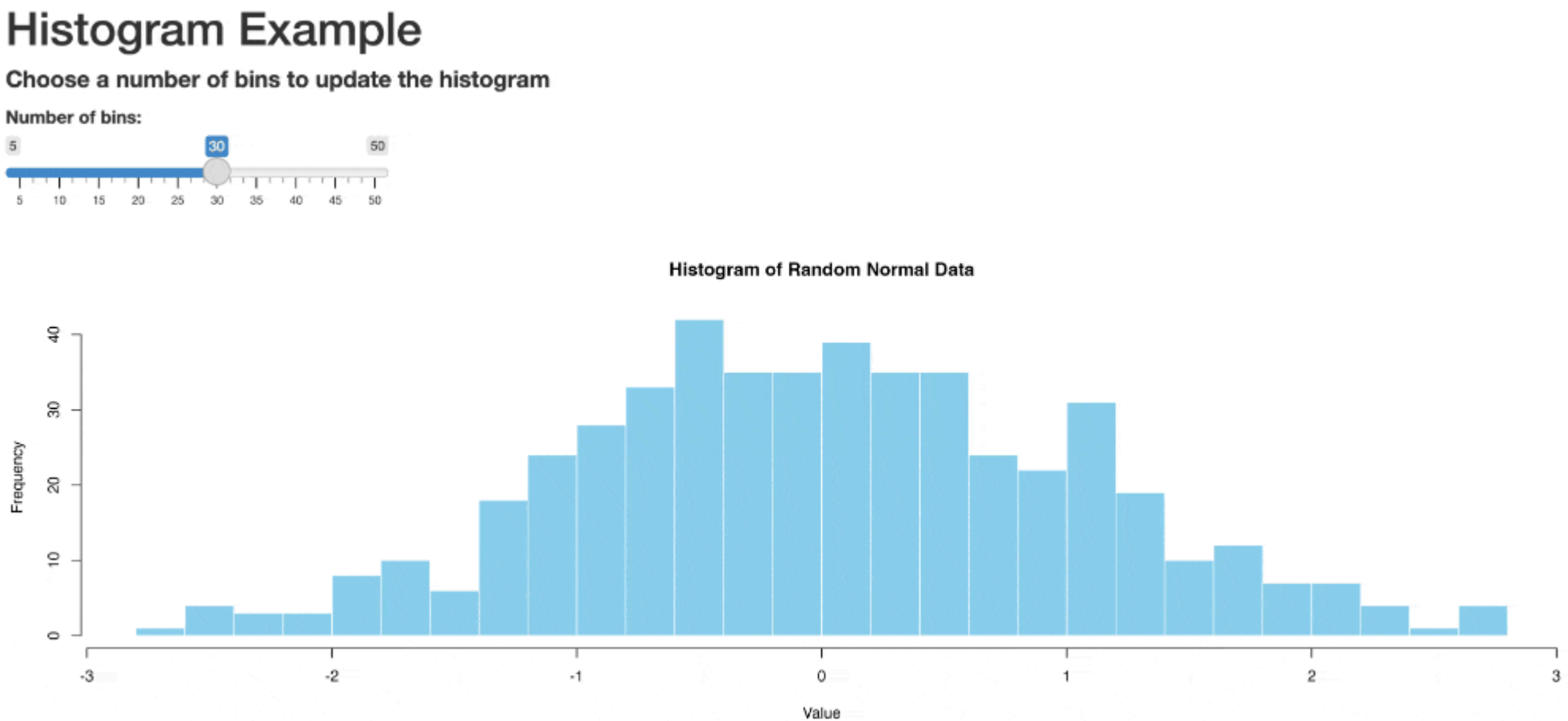
Code Breakdown: Server

Server takes the inputs and create a reactive chart

```
server <- function(input, output) {

  output$histPlot <- renderPlot({
    # Generate random data
    data <- rnorm(500)

    # Create histogram with user-specified bins
    hist(data, breaks = 30, col = "skyblue",
         border = "white", main = "Histogram of Random Normal Data",
         xlab = "Value", ylab = "Frequency")
  })
}

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


Running the App

- Save the code to an R script file, e.g., app.R.
- In your R console, run `shiny::runApp("app.R")`



How to make it reactive?

This will not react to user input because the number of bins is always 30.

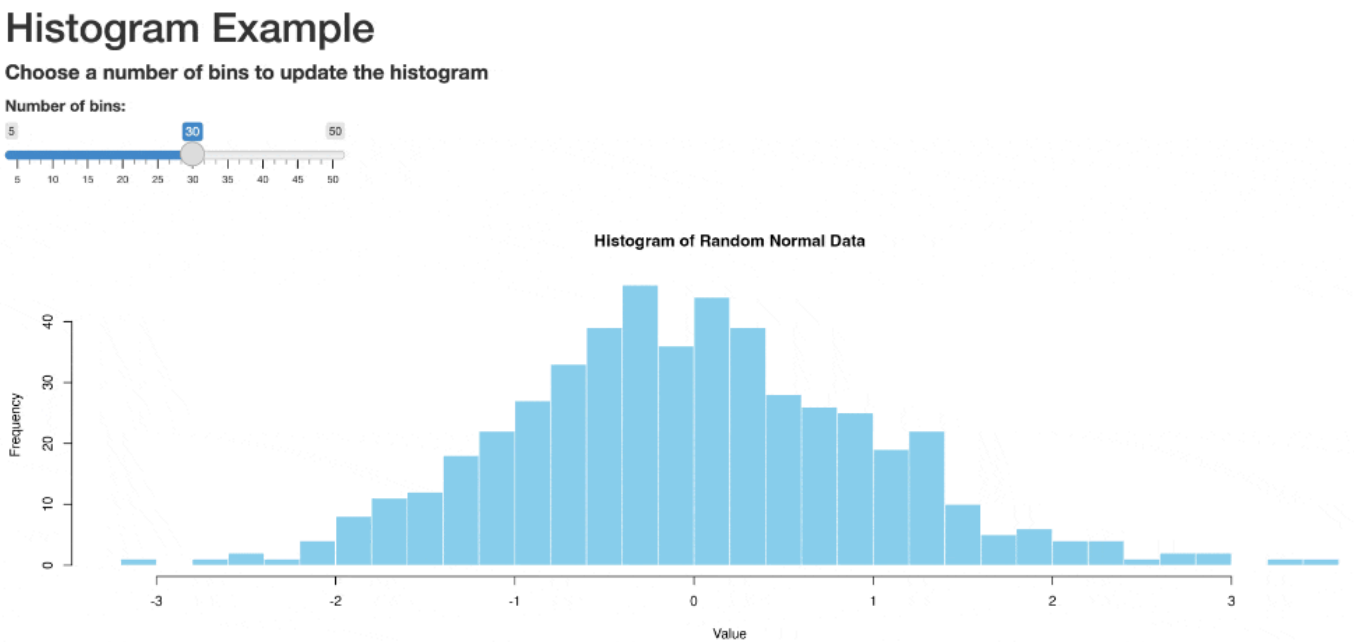
```
server <- function(input, output) {
  output$histPlot <- renderPlot({
    # Generate random data
    data <- rnorm(500)
    # Create histogram with user-specified bin
    hist(data, breaks = 30, col = "skyblue",
         border = "white", main = "Histogram o
         xlab = "Value", ylab = "Frequency")
  })
}

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

This takes in user input and uses it to create a histogram with the specified number of bins.

```
server <- function(input, output) {
  output$histPlot <- renderPlot({
    # Generate random data
    data <- rnorm(500)
    # Create histogram with user-specified bin
    hist(data, breaks = input$bins, col = "sky
         border = "white", main = "Histogram o
         xlab = "Value", ylab = "Frequency")
  })
}

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

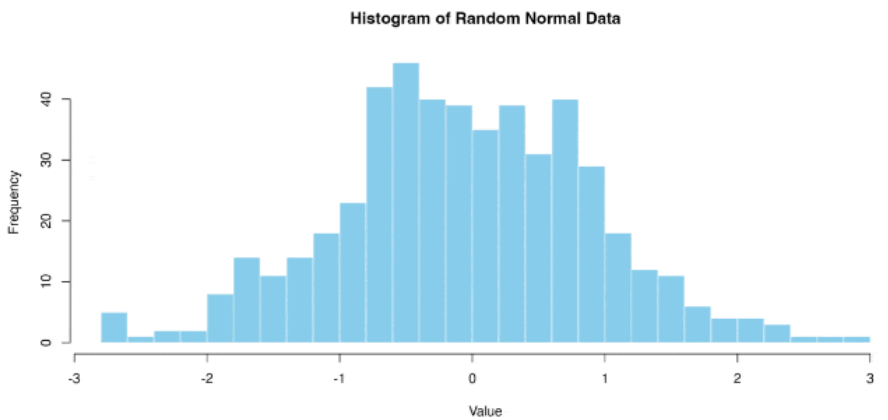

This is what we have now

```
ui <- fluidPage(
  # app title
  h1("Histogram Example"),
  # app subtitle
  h4(strong("Choose a number
  # slider input
  sliderInput("bins",
              "Number of bins
              min = 5, max =
  # histogram output
  plotOutput("histPlot")
)

# Server
server <- function(input, out

  output$histPlot <- renderPl
    # Generate random data
    data <- rnorm(500)

    # Create histogram with u
    hist(data, breaks = input
         border = "white", ma
         xlab = "Value", ylab
  })
```



Adding visual structures

```
ui <- fluidPage(
  titlePanel("Histogram Examp
  h4(strong("Choose a number

  sidebarLayout(
    sidebarPanel(
      sliderInput("bins",
                  "Number of
                  min = 5, ma
    ),

    mainPanel(
      plotOutput("histPlot")
    )
  )
)

# Server
server <- function(input, out

  output$histPlot <- renderPl
    # Generate random data
    data <- rnorm(500)

    # Create histogram with u
```

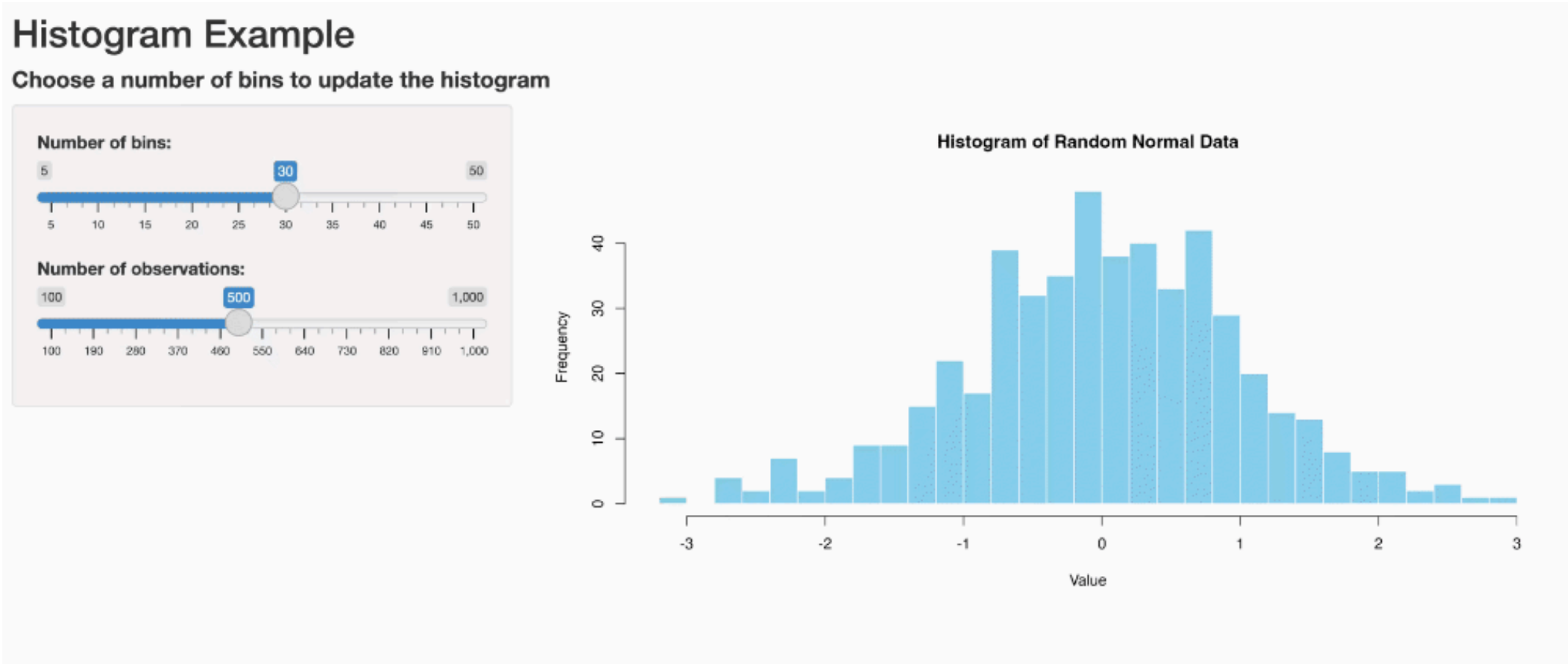


In-Class Activity:

Add a second slider input so that the app reacts to the number of random data points generated for the histogram.

10:00

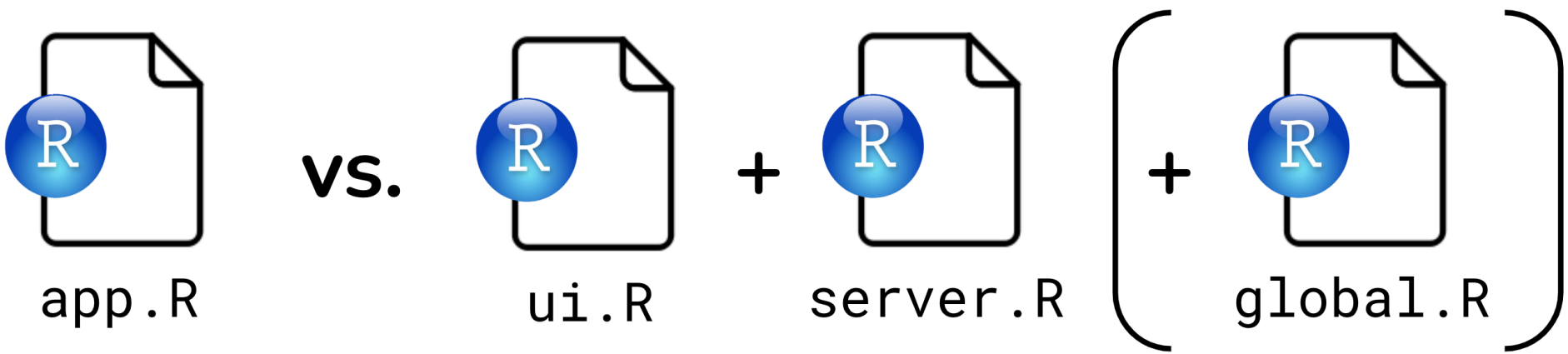
Finished app with two slider inputs



Two-file shiny app with a dataset

In this tutorial, we will build an interactive R Shiny application step-by-step. Our app will:

- Display a scatter plot using the `mtcars` dataset
- Allow users to choose x-axis and y-axis variables
- Enable plot color customization by a third variable
- Label points with car names



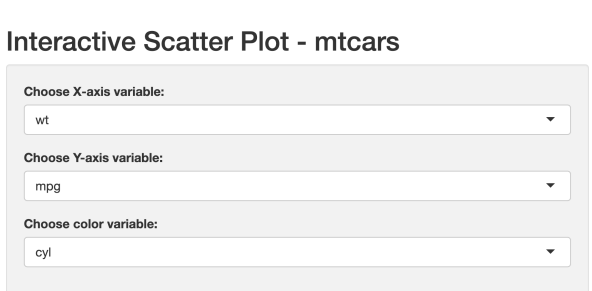
`global.R`: load libraries, clean data

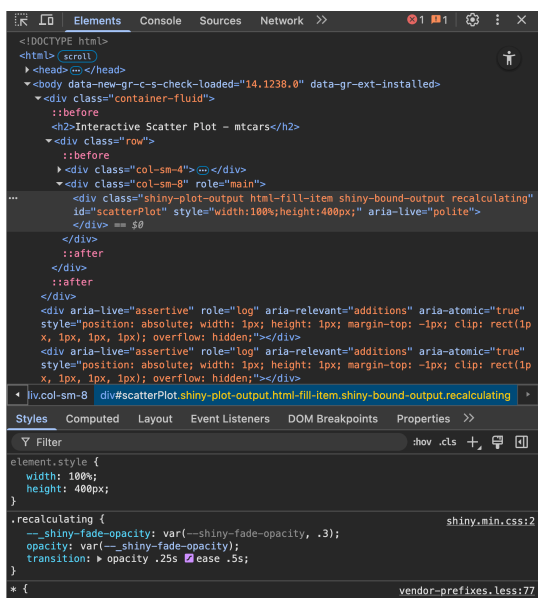
```r
library(shiny)
library(ggplot2)
library(dplyr)

# Data wrangling: Add a car name column and factor variables
mtcars_clean <- mtcars %>%
  tibble::rownames_to_column("car") %>%
  mutate(
    cyl = as.factor(cyl),
    gear = as.factor(gear)
  )
glimpse(mtcars_clean)
```

```
Rows: 32
Columns: 12
$ car  <chr> "Mazda RX4", "Mazda RX4 Wag", "Datsun 710", "Hornet 4 Drive", "Ho…
$ mpg  <dbl> 21.0, 21.0, 22.8, 21.4, 18.7, 18.1, 14.3, 24.4, 22.8, 19.2, 17.8,…
$ cyl  <fct> 6, 6, 4, 6, 8, 6, 8, 4, 4, 6, 6, 8, 8, 8, 8, 8, 8, 4, 4, 4, 4, 8,…
$ disp <dbl> 160.0, 160.0, 108.0, 258.0, 360.0, 225.0, 360.0, 146.7, 140.8, 16…
$ hp   <dbl> 110, 110, 93, 110, 175, 105, 245, 62, 95, 123, 123, 180, 180, 180…
$ drat <dbl> 3.90, 3.90, 3.85, 3.08, 3.15, 2.76, 3.21, 3.69, 3.92, 3.92, 3.92,…
$ wt   <dbl> 2.620, 2.875, 2.320, 3.215, 3.440, 3.460, 3.570, 3.190, 3.150, 3.…
$ qsec <dbl> 16.46, 17.02, 18.61, 19.44, 17.02, 20.22, 15.84, 20.00, 22.90, 18…
$ vs   <dbl> 0, 0, 1, 1, 0, 1, 0, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0,…
$ am   <dbl> 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,…
$ gear <fct> 4, 4, 4, 3, 3, 3, 3, 4, 4, 4, 4, 3, 3, 3, 3, 3, 3, 4, 4, 4, 3, 3,…
$ carb <dbl> 4, 4, 1, 1, 2, 1, 4, 2, 2, 4, 4, 3, 3, 3, 4, 4, 4, 1, 2, 1, 1, 2,…
```


ui.R: define user interface

```
ui <- fluidPage(
  titlePanel("Interactive Scatter Plot - mtcars"),

  sidebarLayout(
    sidebarPanel(
      selectInput("xvar", "Choose X-axis variable:", choices = names(mtcars), selected = "wt"),
      selectInput("yvar", "Choose Y-axis variable:", choices = names(mtcars), selected = "mpg"),
      selectInput("colorvar", "Choose color variable:", choices = names(mtcars), selected = "cyl"),
    ),
    mainPanel(
      plotOutput("scatterPlot")
    )
  )
)
```

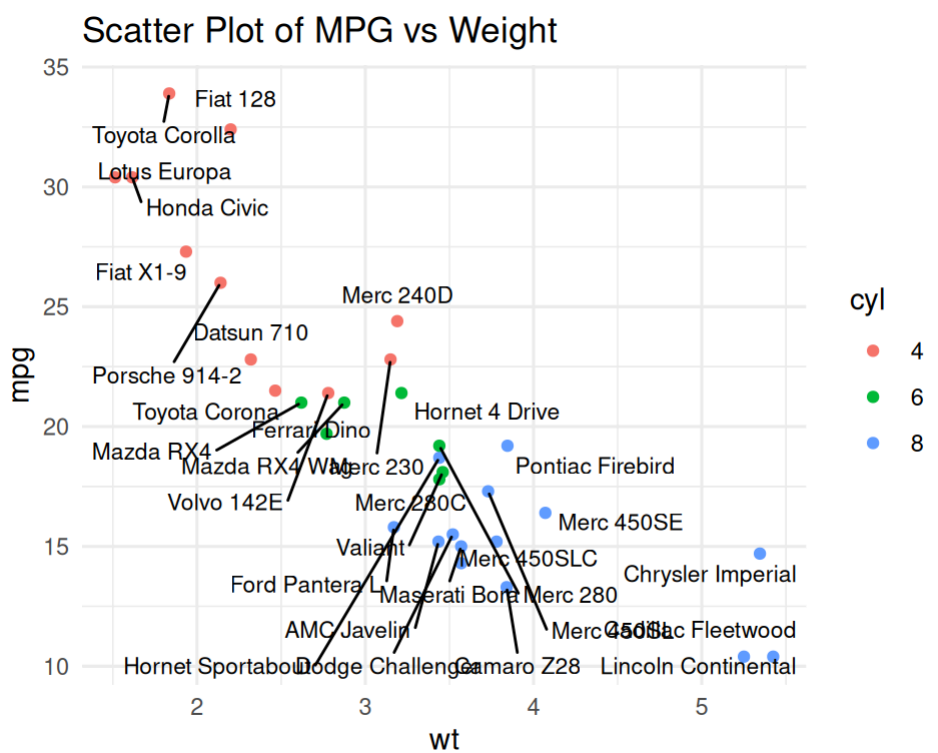




Intermediate step: make ggplot in `scratch.R`

This is not a must but highly recommend, you can test out your ggplot code in a separate R script file, e.g., `scratch.R`, before integrating it into the Shiny app.

```
ggplot(mtcars_clean, aes(x = wt, y = mpg)) +
  geom_point(aes(color = cyl)) +
  ggrepel::geom_text_repel(aes(label = car), vjust =
  labs(
    title = "Scatter Plot of MPG vs Weight"
  ) +
  theme_minimal()
```



server.R: adapt regular ggplot code

scratch.R

```
ggplot(mtcars_clean, aes(x = wt, y = mpg)) +
  geom_point(aes(color = cyl)) +
  geom_text(aes(label = car), vjust = -1, size
  labs(
    title = "Scatter Plot of MPG vs Weight"
  ) +
  theme_minimal()
```

- Regular ggplot code for scatter plot
- x-axis is wt
- y-axis is mpg
- color by cyl
- label points with car names

server.R

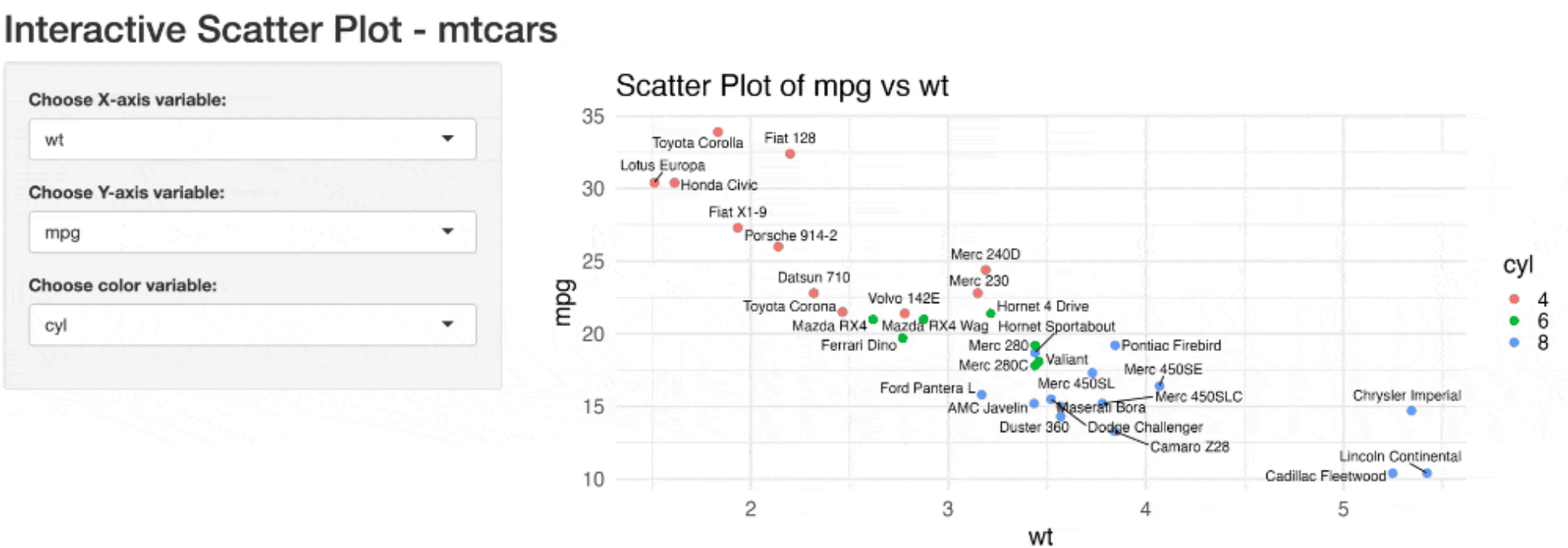
```
server <- function(input, output) {
  # Render the plot
  output$scatterPlot <- renderPlot({
    ggplot(mtcars_clean, aes_string(x = input$
      geom_point(aes_string(color = input$colo
      geom_text(aes(label = car), vjust = -1,
      theme_minimal() +
      labs(title = paste("Scatter Plot of", in
           x = input$xvar, y = input$yvar)
  })
}
```

- Adapt the ggplot code to use `aes_string()` for dynamic variable selection
- Use `input$xvar`, `input$yvar`, and `input$colorvar` to make the plot reactive

Run the two-file Shiny app

No need for `shinyApp(ui = ui, server = server)` when you have two-file app structure:

- Save the `ui.R` and `server.R` files **in the same directory**
- Shiny automatically stitch them together, and optionally look for `global.R`.
- In RStudio, click the **Run App** button



Outline for today

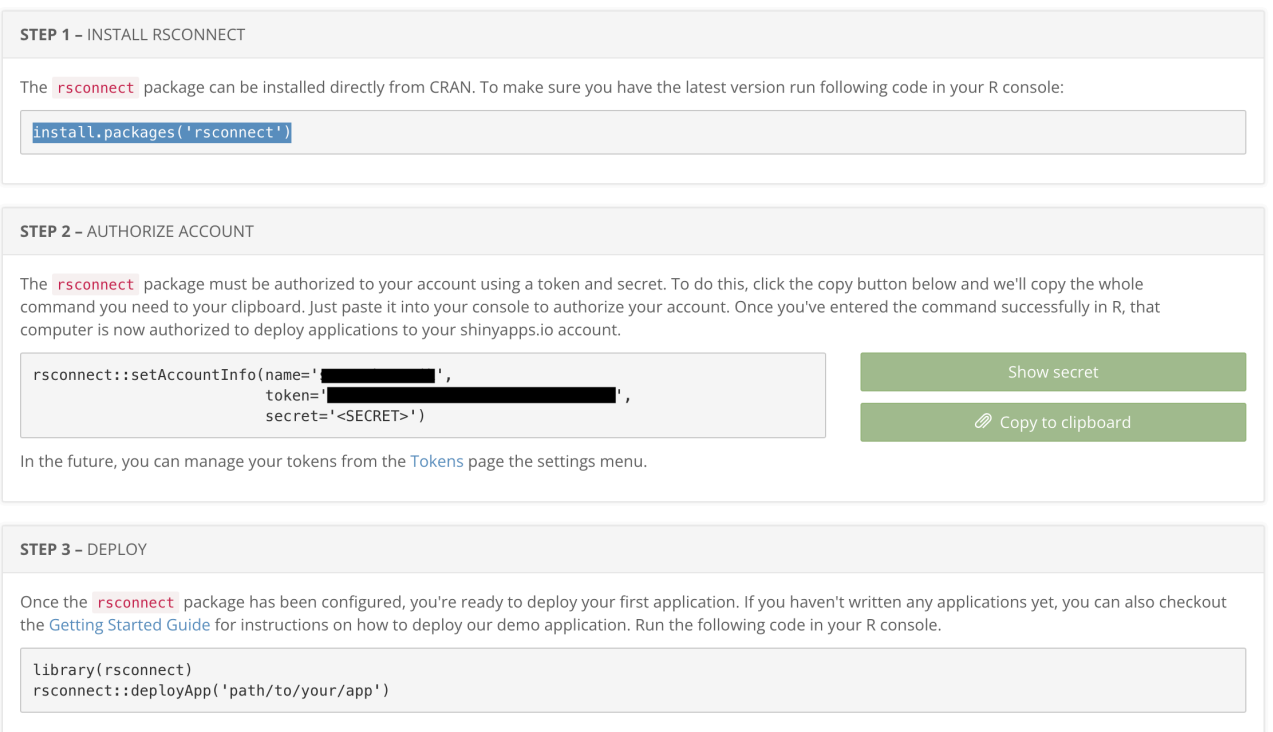
- What is R Shinny
- Write a basic R shiny app
- **Deploy your Shiny apps with shinyapps.io**
- AI-powered help: using Shiny Assistant

Why `shinyapps.io`?

- **Free**: Free tier available for up to 5 small apps
- **Easy to use**: No need to set up a server or manage infrastructure
- **Scalable**: Can handle apps of varying sizes and complexities
- **Integration with RStudio**: Seamless deployment from RStudio IDE

Getting started with `shinyapps.io`

- Create an account on shinyapps.io
- **Recommended** to log in using GitHub
- Install the `rsconnect` package in R: `install.packages("rsconnect")`
- Following the instructions on the shinyapps.io to authorize your account

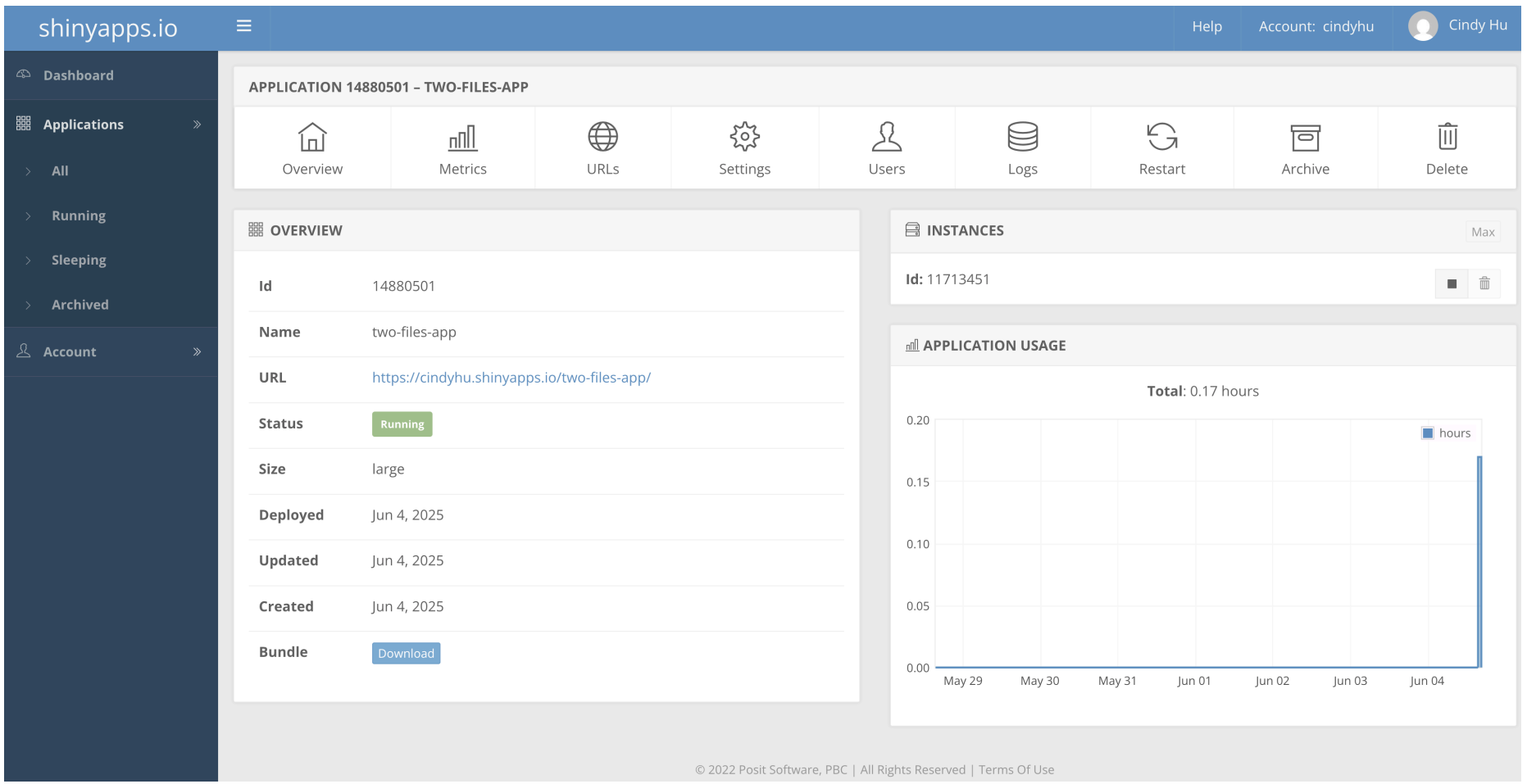


Deploy your app to `shinyapps.io`

- In RStudio, open the app you want to deploy
- Click on the **Publish** button in the top right corner of the RStudio IDE
- Select the shinyapps.io account you just connected
- Fill in the app name and description
- Click **Publish** to deploy your app
- Once deployed, a browser will open to your application. `https://{your-username}.shinyapps.io/{your-app-directory-name}`
- You should see a `rsconnect/` folder within your app directory, which contains the deployment information. **This should be added and committed into version control (i.e. push it to GitHub)**

shinyapps.io dashboard

Dashboard provides an overview of your deployed apps, including: app name and URL, deployment status, usage statistics (e.g., number of active users, CPU usage)



Check out shinyapps.io user guide for more information on hosting your app!

Outline for today

- What is R Shinny
- Write a basic R shiny app
- Deploy your Shiny apps with shinyapps.io
- **AI-powered help: using Shiny Assistant**

What is Shiny Assistant?

https://gallery.shinyapps.io/assistant/

R Python Concise

Hello, I'm Shiny Assistant! I'm here to help you with Shiny, a web framework for data driven apps. You can ask me questions about how to use Shiny, to explain how certain things work in Shiny, or even ask me to build a Shiny app for you.

Here are some examples:

- "How do I add a plot to an application?"
- "Create an app that shows a normal distribution."
- "Show me how make it so a table will update only after a button is clicked."
- Ask me, "Open the editor", then copy and paste your existing Shiny code into the editor, and then ask me to make changes to it.

Let's get started! 🚀

Who can see my activity?

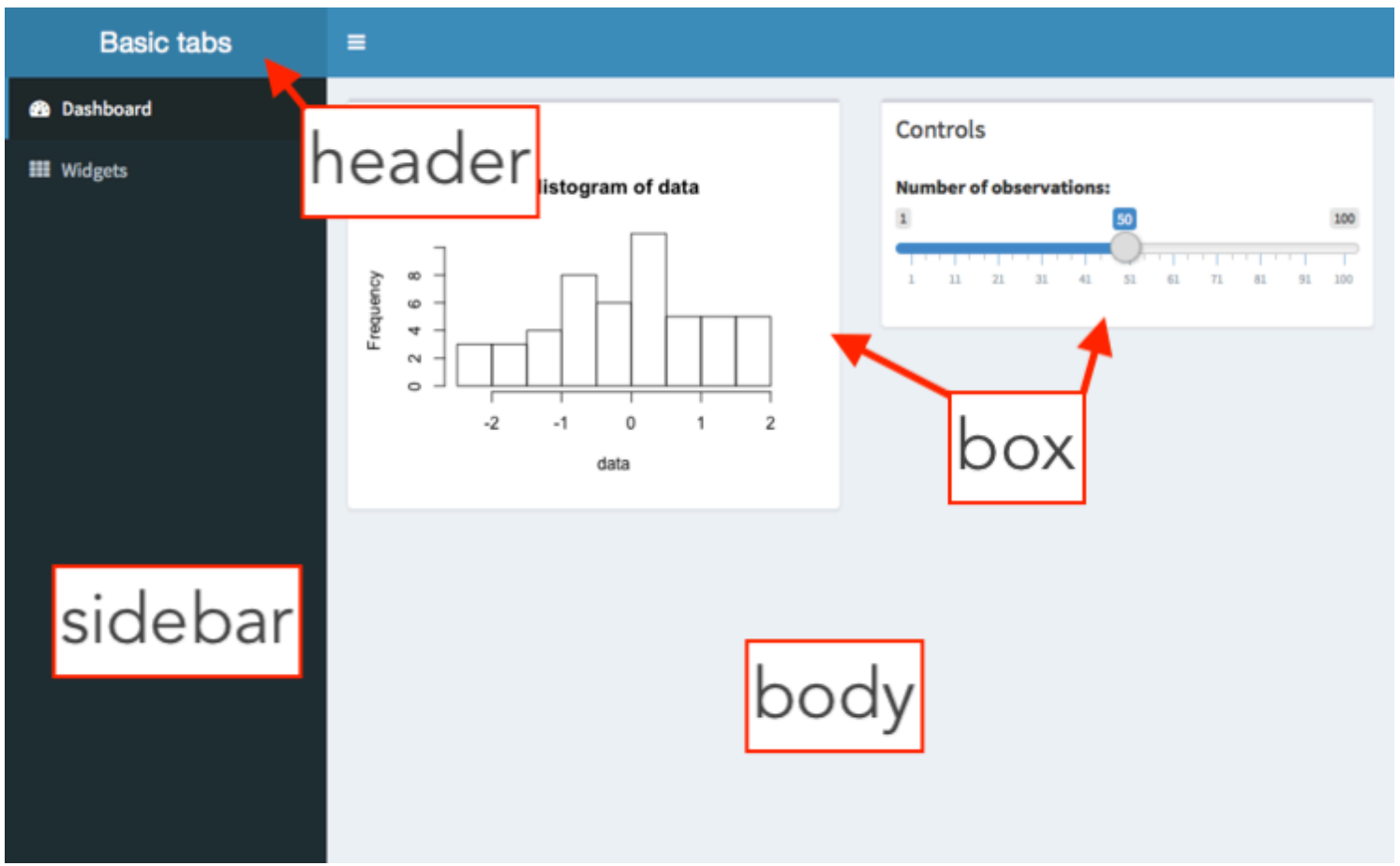
Enter a message...

Use Shiny Assistant to recreate the two-file shiny app

> **Prompt**: Create a shiny app using the mtcars dataset. Use three files global.R, ui.R, server.R. The app displays an interactive scatter plot that reacts to user input of x-axis, y-axis, and a third variable for color of the points. Show car name as label text next to the points.

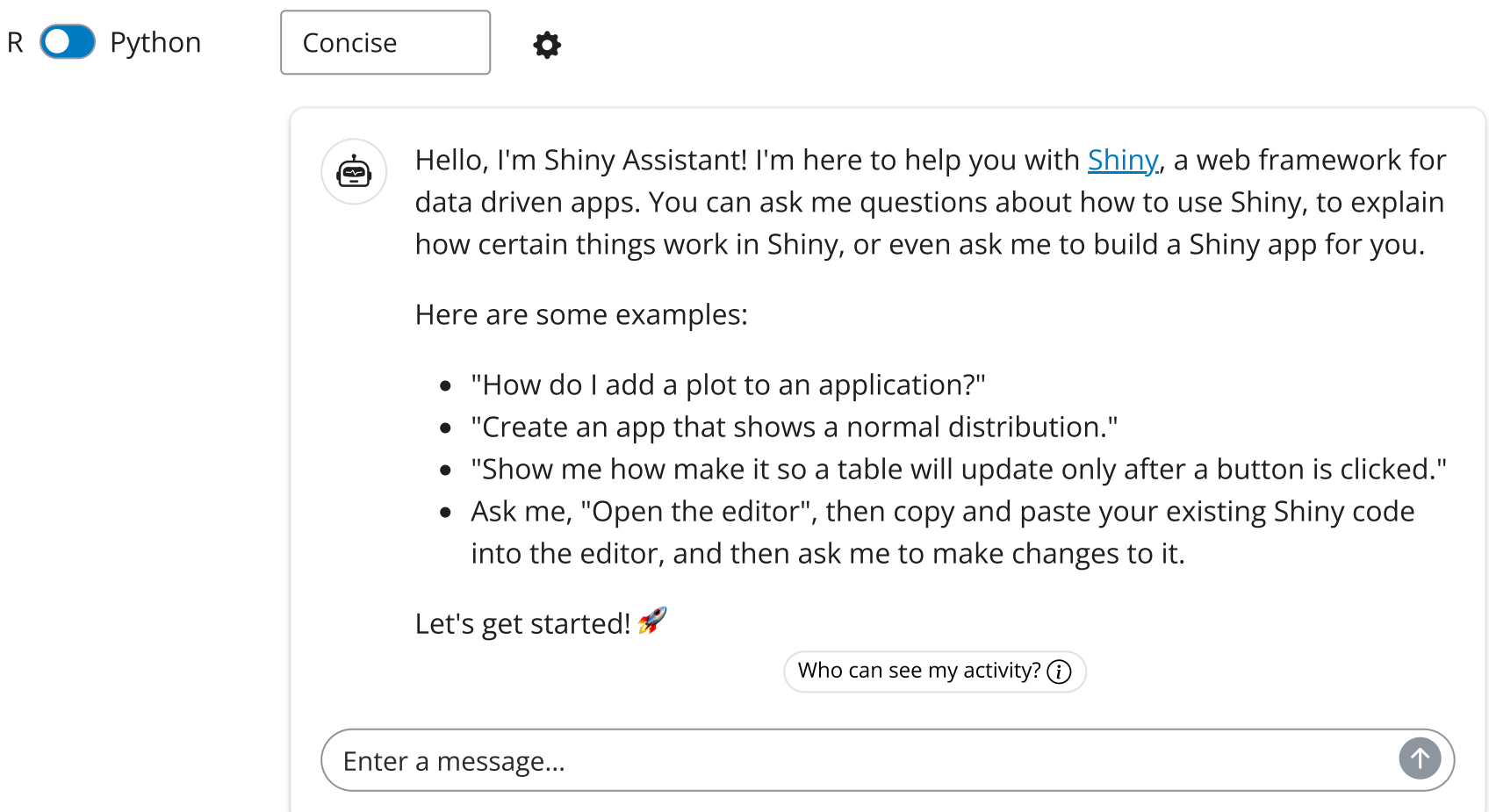
Next, let's build a `shinydashboard`

> The `{shinydashboard}` package provides a framework for building dashboards in R Shiny. It allows you to create visually appealing and interactive apps with a more classic "dashboard" layout, including sidebars, tabs, and boxes. You need both packages: `{shiny}` and `{shinydashboard}`.



Use Shiny Assistant to create a `shinydashboard`

> **Prompt**: Create a shinydashboard using the mtcars dataset. Use three files global.R, ui.R, server.R. The app allows users to filter by mpg and displays three output: an interactive scatter plot that reacts to user input of x-axis, y-axis, and color variable. A heatmap of car performance. And a data table of the filtered dataset. Show car name as label text next to the points in the scatter plot.



Refine the app locally

- Download the code from Shiny Assistant

- Save the files in your local R project directory, remember to organize your repo structure well
- Open the files in RStudio and run the app locally
- Make any necessary adjustments to the code

Your turn in hw4

Try one of these built-in datasets to explore with Shiny Assistant

Dataset	Description
`mtcars` 🚗	Car performance data (mpg, cylinders, hp)
`iris` 🌸	Iris flower measurements (sepal, petal, species)
`diamonds` 💎	Diamond pricing (carat, cut, price, etc.)
`faithful` 🌋	Old Faithful geyser eruptions (duration, waiting time)
`airquality` 🌍	New York air quality data (Ozone, Temp, Wind)
`ToothGrowth` 🦷	Vitamin C & tooth growth in guinea pigs

Or upload your own dataset to GitHub and give Shiny Assistant a public URL!

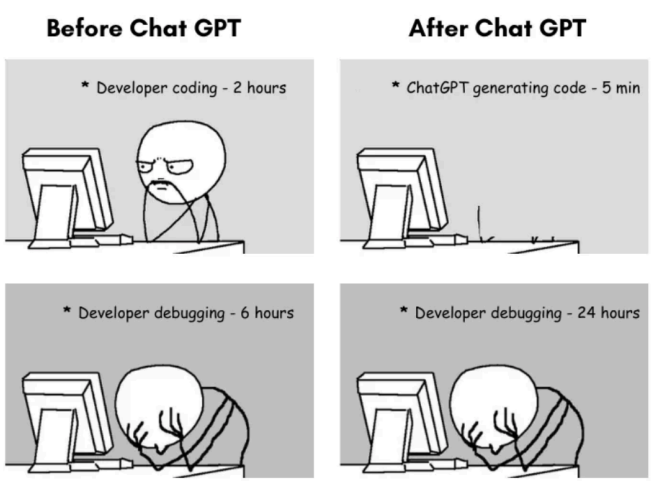
Write good prompt, and you will get good code!

Describe what change you made to the app on top of what Shiny Assistant generated.

Further resources

How much time do you have?

- **10 min**: Print out this Shiny for R cheatsheet
- **2.5 hrs**: Follow this Posit tutorial
- **Lifetime**: Check out resources like the `Shiny Gallery`, `TidyTuesday`, and `Mastering Shiny` book
- **Unknown**: chatGPT, Gemini, Shiny Assistant (powered by Anthropic), and other AI tools can help you build Shiny apps



End-of-Class Survey

Fill out the end-of-class survey

~ This is the end of Lecture 4 ~

10:00