Using Shiny in a Modern Workflow for Statistics

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Outline

- **What?**
- **Why?**
- **How?**
- **Example 1**: *Mapping County Parks in Miami*
- **Example 2**: *Bayesian test for skewness*

What?

What is a Shiny app?

- A web application constructed using the `Shiny` package developed and maintained by RStudio

- Provides a flexible framework allowing `R` code to exist and run on the web

- Can run locally, on a server, or for free on the RStudio cloud

- Whatever `R` can do locally, it can also do on the web with Shiny!

Fun Examples

- ***Papr:*** The “Tinder” of academic papers

- ***CDC Disease Monitor:*** Display weekly case counts of various diseases from CDC data

- ***Genome Browser:*** Visualize genomes using Circos diagrams

Why?

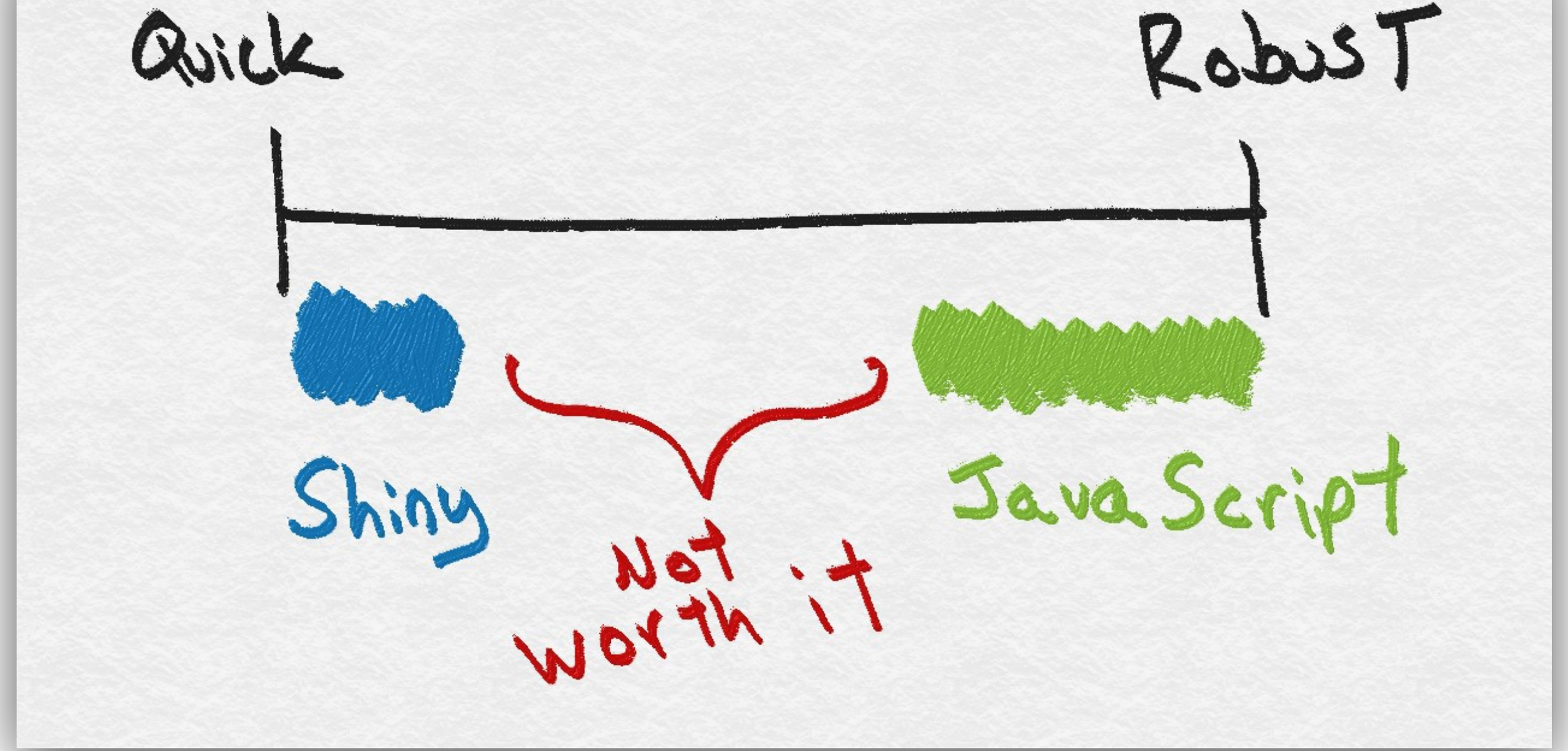


Photo credit: Jacqeuline Nolis (@skyetera)

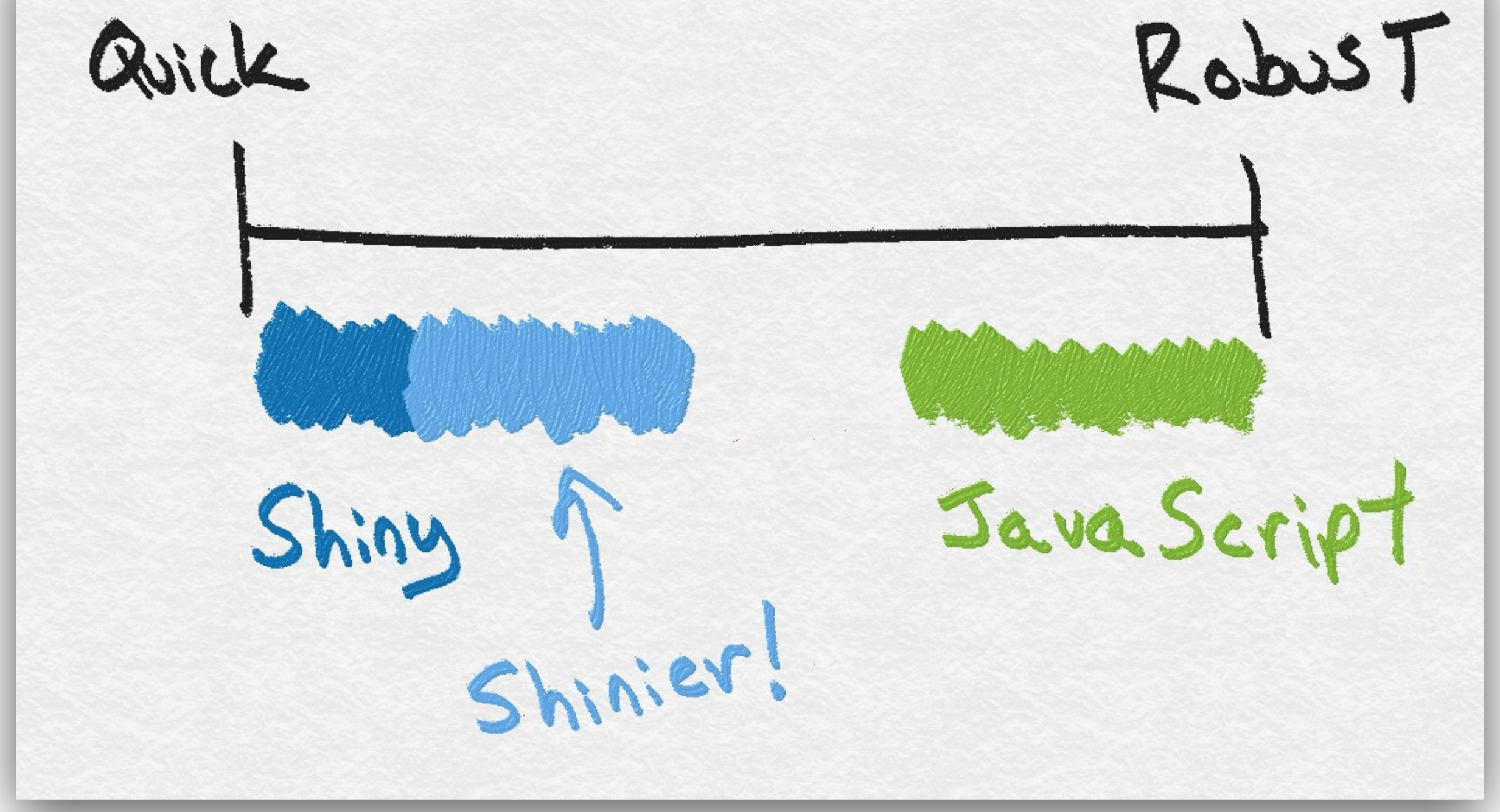


Photo credit: Jacqeuline Nolis (@skyetera)

Why use a Shiny app?

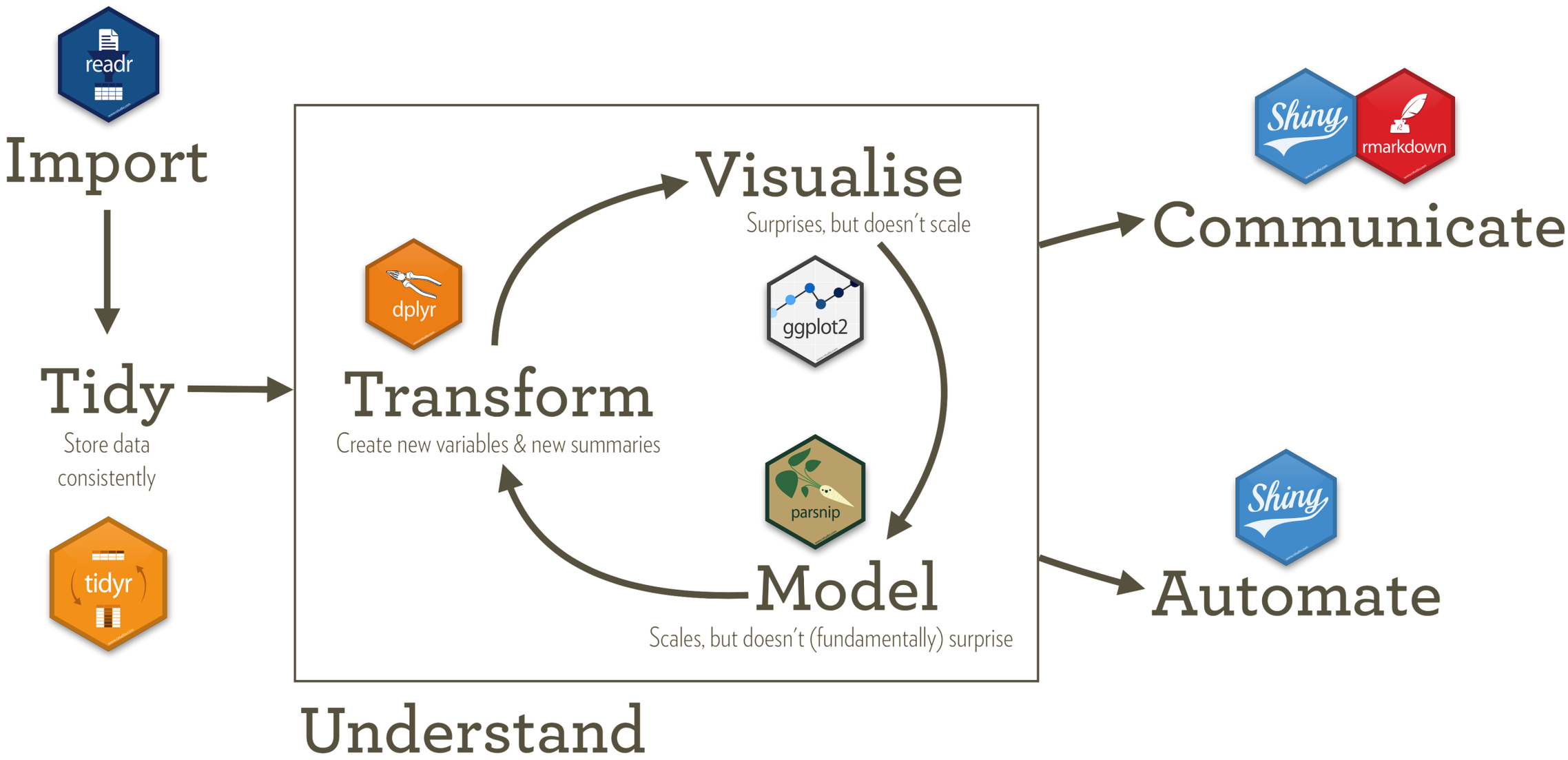
- A statistical analysis can (should) be thought of as a *system* that **must be able to iterate more than once** (reproducibility).

- Some components of the system are “high-touch” and some are more automated.

- For the entire system to work, we must dedicate thought and effort to **every** component, not just statistical methods.

- The statistician designs, constructs, and maintains the system then shares it with others.

A Statistical System



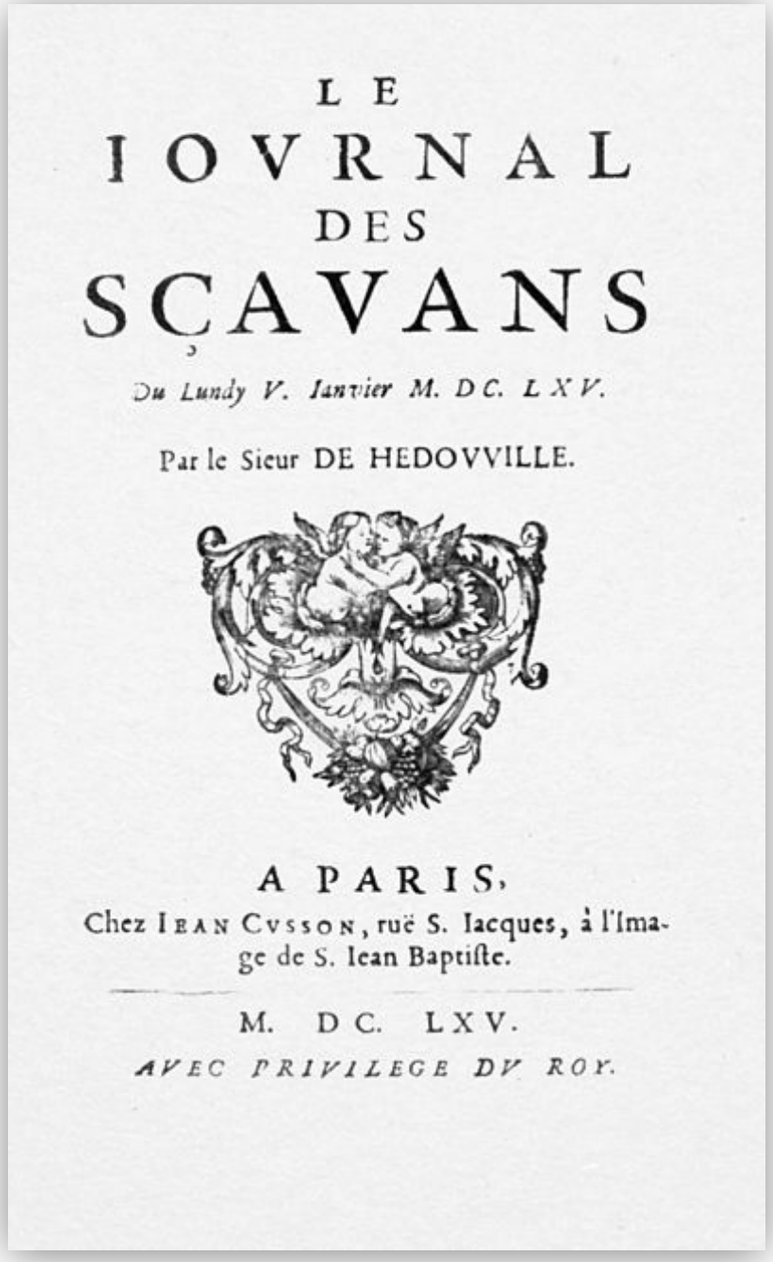
Hadley Wickham, 2018: "Should all Statistics students be Programmers?"

Shiny for Communication

- Academic communication is done primarily through the medium of the journal.

- Modern data analysis is often performed through the medium of highly customized software (not highly compatible with the scientific journal).

- **Our tools for communication should reflect the different media in which we work.**



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Par le Sieur DE HEDOVVILLE.

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First known academic journal in Europe: *Journal des sçavans* (began publishing in **1665**)

Shiny for Education

- Core statistics concepts often involve lots of abstract visual imagination
    - Conditional probability/Bayes Theorem
    - Sampling distributions/CLT
- Shiny apps can serve as interactive visual teaching aids
    - Penn State's "Book of Apps for Teaching Statistics"
- Still, Shiny is probably most promising for communicating research

How?

Three Core Functions

```
ui <- shiny::fluidPage(…)
```

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

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

Three Core Functions

- The `ui, server,` and `shinyApp` functions can all be called from one single .R file, usually named `app.R`

- All `R` packages used by the app should be loaded at the top of the `app.R` file

- Alternatively, the `ui` and `server` functions can exist in their own `.R` files

- From the console, use `runApp("app.R")` to run the app. In RStudio, there is a GUI for this

User Interface

- The **user interface** allows for transfer of data between the the user and the "back-end" machinery of the application. It is the "cell membrane" of the application.

- User communicates with the app to provide things like:
    - Input data, simulation parameters, search queries, etc…
- App communicates with the user to provide things like:
    - Output data, simulation results, search results, etc…
- **All interactions between the user and app take place through the UI**

User Interface

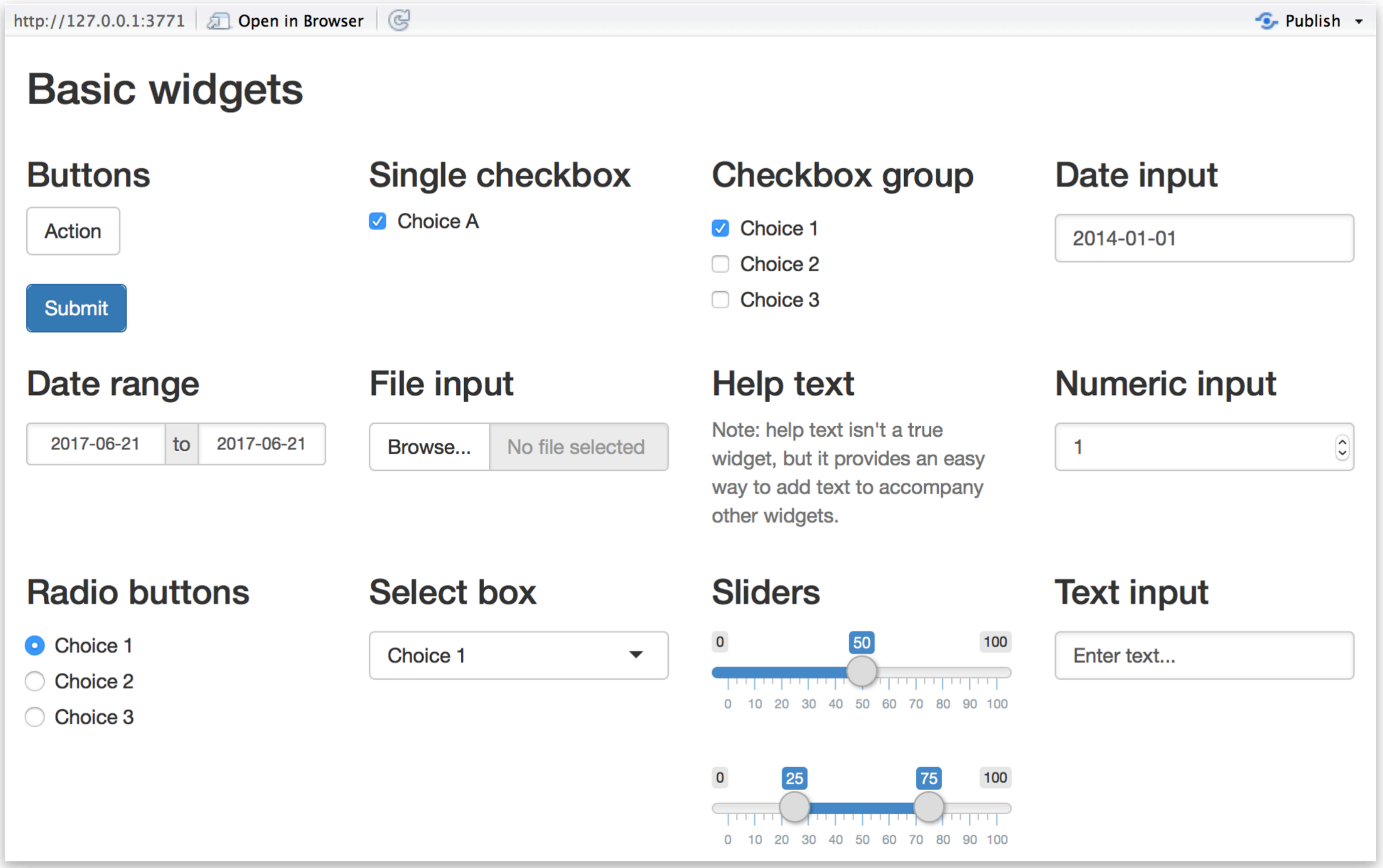
- With `shiny`, the user interface is an `R` object (conventionally named `ui`) defined with several possible functions.

  - **UI Layout functions**: designate where elements live on the webpage (title page, free text, input/output).

  - **UI Input functions**: construct simple input widgets such as slider bars, text entry, file upload etc…

  - **UI Output functions**: control the application's output such as plots, text, file downloads etc…

Control widgets



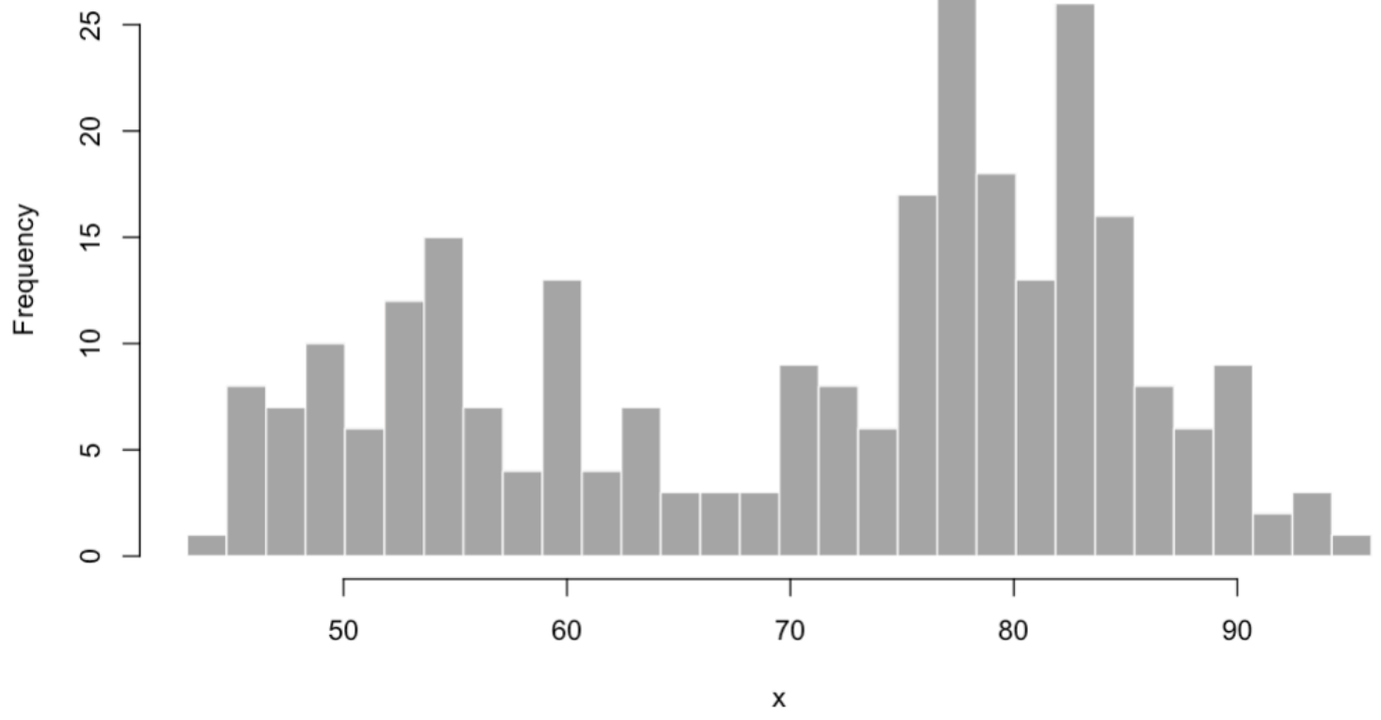
http://127.0.0.1:7488 | Open in Browser | Publish

Old Faithful Geyser Data

Number of bins:

1 30 50

1 6 11 16 21 26 31 36 41 46 50



```r
# Define UI for application that draws a histogram
ui <- fluidPage(

    # Application title
    titlePanel("Old Faithful Geyser Data"),

    # Sidebar with a slider input for number of bins
    sidebarLayout(
        sidebarPanel(
            sliderInput("bins",
                        "Number of bins:",
                        min = 1,
                        max = 50,
                        value = 30)
        ),

        # Show a plot of the generated distribution
        mainPanel(
           plotOutput("distPlot")
        )
    )
)
```

Server

- In a shiny app, **`server`** is a function defined with two parameters:
  - **`input`**: Used to access all parameters defined in the UI.
    - Ex: `input$bins` will retrieve the current value of chosen number of histogram bins
  - **`output`**: Used to update the displayed objects defined in the UI layout

```r
# Define server logic required to draw a histogram
server <- function(input, output) {

    output$distPlot <- renderPlot({
        # generate bins based on input$bins from ui.R
        x    <- faithful[, 2]
        bins <- seq(min(x), max(x), length.out = input$bins + 1)

        # draw the histogram with the specified number of bins
        hist(x, breaks = bins, col = 'darkgray', border = 'white')
    })
}
```

Server

- Tendency is for backend to become cluttered and inefficient since not seen by the user.

- For complex apps, avoid this issue by making an `R` package.

Tips for good server functions

1. If code does not need to be **reactive** to user input, isolate it outside the server (ex: reading data)

2. Write an `R` package for any custom functions you use. Shiny will only need to load the package once (rather than re-allocating memory for the function after each refresh).

3. Use delayed evaluation when possible to avoid unnecessary computation (ex: ggplots)

Reactive Programming

- Reactive expressions are those that fetch data from the user interface and cache their values.

- Much of the computational burden in a Shiny app comes with transferring data between the UI and the served side.

- By using the `reactive({})` function, you can **control when the app fetches data from the UI.**

- **Shiny will even know to skip fetching parameters which are already up to date.**

Dependencies

- Reactive expressions are like links in a chain connecting `input` values to `output` objects.

- Using a reactive programming will eliminate issues of dependency (ex. A plot is updated but the data it relies on is not).

- Shiny will update an output object if:

    1. An `input` value in the object's `render*` function changes

    2. A reactive expression in the object's `render*` function becomes obsolete

General Advice

- Shiny apps work very well with R Projects and R Packages. These tools take effort to learn but will ease the organizational burden.

- If not using R Projects & R Packages, put apps in their own directory on your computer and define any custom functions in a separate file (called `helper.R` or something).

    - Source this file at the top of the app with `source("helper.R")` to be able to use the custom functions.

Testing apps

- Once your Shiny app is running well locally, the next step is to test it before going live.

- `shinytest` is an R package to help automate the testing process.

- See RStudio's vignette for `shinytest`

Deploying Apps

- RStudio provides a range of hosting options for Shiny apps ranging from free and easy to use solutions to more powerful solutions that require a subscription fee and technical skill.

- https://www.shinyapps.io/ is the best solution for most users

Examples

Helpful Links

- A compilation of links and materials used can be found at https://github.com/carter-allen/brownbag