STAT5003

Week 1: Shiny interactive graphics

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Overview of a Shiny app

What is a Shiny app?

- An `R` package that creates interactive web applications
  - without needing to know HTML, CSS, or JavaScript
- Combines two things
  - Statistical Power of
    - Use any analysis that can be coded in `R`.
  - Interactivity via web browser
    - Any modern web browser can work
    - **Reactive** output expressions.

What is reactive output?

- Output of program/interface reacts to user input
- Not a new concept at all
    - Easiest pervasive example of this is MS Excel!
- Exercise for interested reader: Shiny apps equivalent

Deployment of applet.

- Local deployment: Can run on any machine with R installed and a modern web browser. Syntax below
    - `> shiny::runApp(<path-to-my-app>)`
- Hosted on shinyapps.io
    - RStudio server built to host shiny apps (free and paid options).
- Server side deployment:
    - Can host the app on a server running the Rstudio server software.

Basic File Format of Applet.

- Two ways
  - Newer: Single file **app.R**
  - Older legacy way: Two Files
    - **server.R** (Analysis code)
    - **ui.R** (Display code)

Basics of an App

Open `apps/intro-01.R`

```r
library(shiny)

# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- Controls layout and appearance
  - user input area
  - output drawn
  - It really is HTML/CSS/Javascript
- Server needs code to
  - deal with inputs

Skeleton of standalone app file

```r
library(shiny)

# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- Four essential parts

Skeleton of standalone app file

```r
library(shiny)

# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- A call of the `shiny` library.

Skeleton of standalone app file

```r
library(shiny)


# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- A definition of the **u**ser **i**nterface (**ui**)
    - Inputs and where they are
    - Where the outputs should be
    - HTML/Javascript/CSS goes here

Skeleton of standalone app file

```r
library(shiny)

# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- Server code instructions/recipe
  - How the server should create output from user input
  - When to **listen** for input changes (i.e. **reactive**)

Skeleton of standalone app file

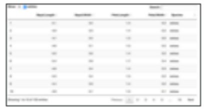
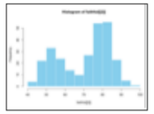
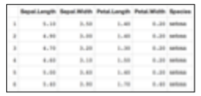
```r
library(shiny)

# Define UI
ui <- fluidPage()

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

# Run the application
shinyApp(ui = ui, server = server)
```

- A call to run the application.

Place Output in App - Two main families of functions

- `*Output` set that anchors the output in the UI
- `render*` set that tells Shiny how to make the output
- Segue: `R` is a sequential language
    - Classic `R`, each line is run sequentially.
    - Reactive language is not quite the same.
    - Shiny decides when to react.
    - When it reacts, it needs instructions to carry out!
    - You give Shiny instructions to do a set of tasks.
    - Shiny does the tasks, in the order it wants.

render *and* Output Links

Visual Output	render*		*Output
	DT::renderDataTable(expr,...)	⇔	dataTableOutput(outputId)
	renderImage(expr,...)	⇔	imageOutput(outputId,...)
	renderPlot(expr,...)	⇔	plotOutput(outputId,...)
`'data.frame': 3 obs. of 2 variables:` `$ Sepal.Length: num 5.1 4.9 4.7` `$ Sepal.Width : num 3.5 3 3.2`	renderPrint(expr,...)	⇔	verbatimTextOutput(outputId)
	renderTable(expr,...)	⇔	tableOutput(outputId)
foo	renderText(expr,...)	⇔	textOutput(outputId, ...)
	renderUI(expr,...)	⇔	uiOutput(outputId, ...)

Example: put *Output call in UI.

```r
library(shiny)


ui <- fluidPage(
        plotOutput("myShinyPlot")
)

server <- function(input, output) {}

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

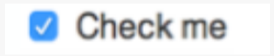
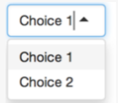
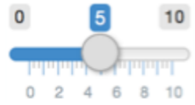
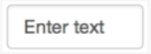
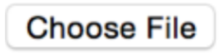
- `*Output(<outputId>)` call goes in the UI area
    - e.g. `plotOutput("myShinyPlot")` shown above

Example: Linking it to server render

```r
library(shiny)

ui <- fluidPage(
        plotOutput("myShinyPlot")
)

server <- function(input, output) {
  output$myShinyPlot <- renderPlot({
    hist(faithful[, 1])
  })
}

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

- `output$<outputId> <- render*(<output code>)` in server area
  - This is a boring plot that isn't interactive!
  - Need a statement with `input$<inputId>` to make it **reactive**!

Basic Reactive Inputs

	actionButton(inputId, label)		numericInput(inputId, label, value)
	actionLink(inputId, label)		passwordInput(inputId, label)
	checkboxGroupInput(inputId, label, choices)		radioButtons(inputId, label, choices)
	checkboxInput(inputId, label)		selectInput(inputId, label, choices)
	dateInput(inputId, label)		sliderInput(inputId, label, min, max)
	dateRangeInput(inputId, label)		textInput(inputId, label)
	fileInput(inputId, label)		

Skeleton Input structure

```
ui <- fluidPage(
    selectInput(inputId = "myInput",...),
    plotOutput(outputId = "myOutput")
)

server <- function(input, output) {
  output$myOutput <- renderPlot({
    plot(x = input$myInput)
  })
}
```

- `input` is an R environment
  - `*Input` put in the UI area
  - objects accessed/references with `input$<inputId>`
  - `<inputId>` is a character string label of your choice
  - **All** inputs require an `<inputId>`
    - Only the old `submitButton` doesn't need an `<inputId>`

Input structure

```
ui <- fluidPage(
    someInput(inputId = "myInput",...),
    someOutput(outputId = "myOutput")
)

server <- function(input, output) {
  output$myOutput <- renderPlot({
    plot(x = input$myInput)
  })
}
```

- The Output is placed in the UI with one of the `*Output` functions
- Server code written which depends on the `input$<inputId>`
  - Can be in the `render*` function
  - Can be in a **reactive** object (more on this later)

Example: Choosing the dataset.

Open `apps/intro-02.R`

```r
ui <- fluidPage(
  selectInput(inputId = "datachoice",
              label = "Choose dataset to view:",
              choices = c("eruptions", "waiting"),
              selected = "eruptions"),
  plotOutput("myShinyOutput")
)
```

Exercise

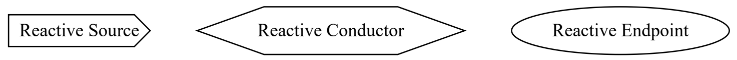
Add another input to the basic faithful histogram app

- Add a slider to control the number of bins with the following arguments
  - **inputId = numBins**
  - **label = "Select number of bins"**
  - **min = 1**
  - **max = 50**
  - **value = 30**
- Use this input variable to control the number of bins as an argument in the **geom_histogram** function. (see `? geom_histogram`, the bins argument)
- Run the app and see the result

Reactive output in Shiny

Reactivity

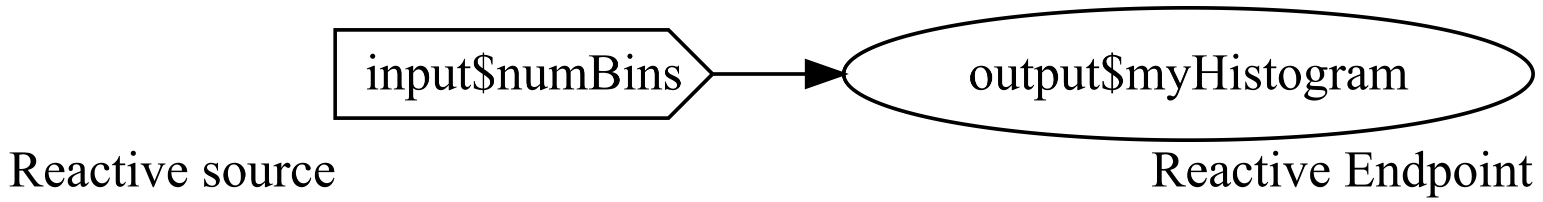
Visual representation



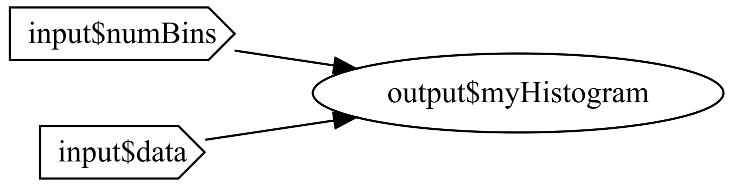
- What are reactive sources?
  - `input` and `reactiveValues`
- What are reactive conductors?
  - `reactive`
- What are reactive endpoints?
  - output objects (`render*`)
  - More generally an `observer`
- **NB**: The node shapes shown here differ slightly to the RStudio shapes on their website.

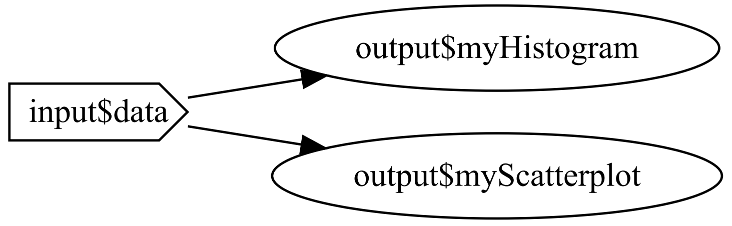
Simple reactivity

- User input is the reactive source
- User output depends directly on the source



Multiple sources and outputs



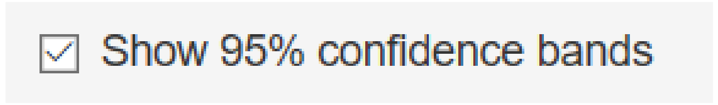
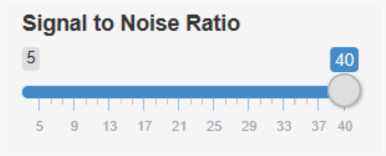
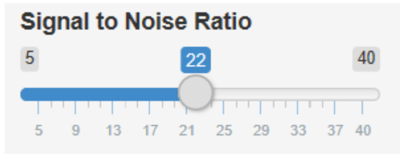


- Sources can impact on multiple outputs.
- Endpoints can depend on multiple sources.

What is `input$<inputId>`?

- `input` is actually an R **environment**
  - Similar to a **list**
- elements accessed with `input$<inputId>`
- **Updates** each time user changes the input in UI.
- Linked to output in the **server** area.

Examples of changing input

User Interface	input$<inputId>
 Show 95% confidence bands	→ input$showBands = TRUE
	→ input$showBands = FALSE
	→ input$n = 128
	→ input$SNRslider = 40
	→ input$SNRslider = 22

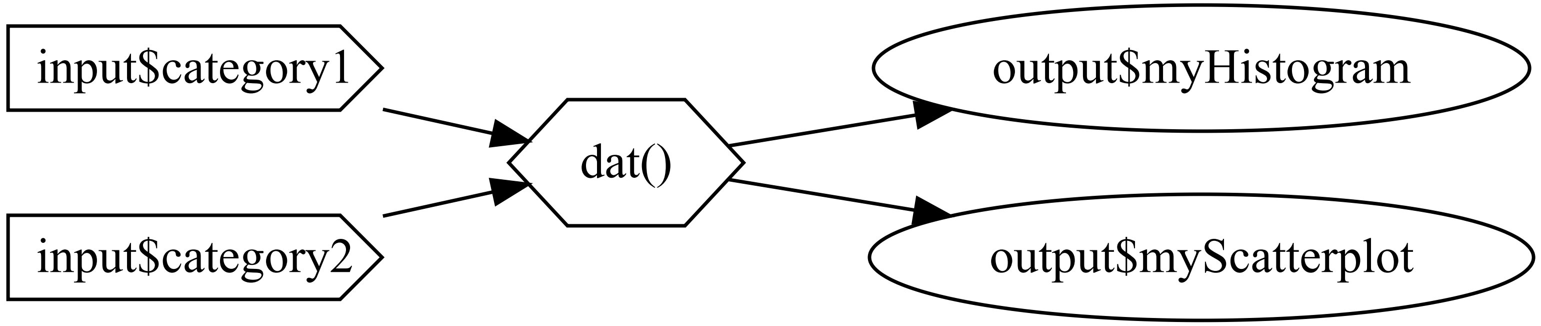
Reactive Output

```r
ui <- fluidPage(
  sliderInput(inputId = "numBins",
              label = "Select number of bins",
              min = 1, max = 50, value = 30),
  plotOutput("myShinyOutput")
)

server <- function(input, output) {
  output$myShinyOutput <- renderPlot({
    ggplot(faithful, aes_string(faithful[, 1])) +
      geom_histogram(bins = input$numBins)
  })
}
```

- **Reacts**: Each time `input$numBins` updates
  - `output$myShinyOutput` is **invalidated** (out of date)
  - Server re-runs `renderPlot` with supplied *recipe*.

Reactive Conductor

- Reactive component between source and endpoint.
- Again can have
    - one or more dependencies (parents)
    - one or more dependents (children)



- Useful if computing the common data takes time.

Reactive object

- A `reactive` object turns a standard expression into a reactive expression.
- Essentially when its inputs change, it
  - re-evaluates itself
  - invalidates everything that depends on it, so they re-evaluate themselves.
- Typical syntax given below.
  - `my_reactive <- reactive({ input$something; other_reactive(); })`
  - `my_reactive()` returns the current value of `my_reactive`
  - `my_reactive` gives the reference or reactive expression.

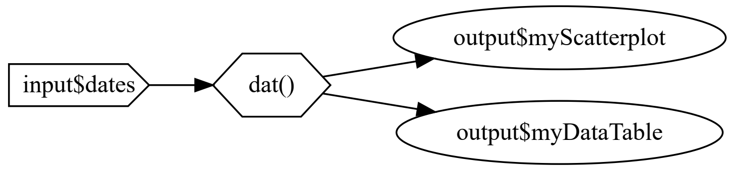
Example: Reactive Conductor

```r
ui <- fluidPage(
  sliderInput(inputId = "n",
    label = "Select number of observations to simulate",
    min = 1, max = 50, value = 30),
  plotOutput("myShinyOutput"),
  verbatimTextOutput("mySummary")
)

server <- function(input, output) {
  dat <- reactive({
    rnorm(input$n)
  })
  output$myShinyOutput <- renderPlot({
    boxplot( dat() )
  })
  output$mySummary <- renderPrint({ summary( dat() })
}
```

- Reactive data, `dat()`, is computed once
  - Used twice!
  - Don't forget the `()` to use it

Example:

- Too many observations in your Data
- Suppose you want to filter by time window



1. Add a UI element to select Date range
2. Filter by date range and assign it as a reactive (reactive conductor)
3. Change the output to depend on the reactive object

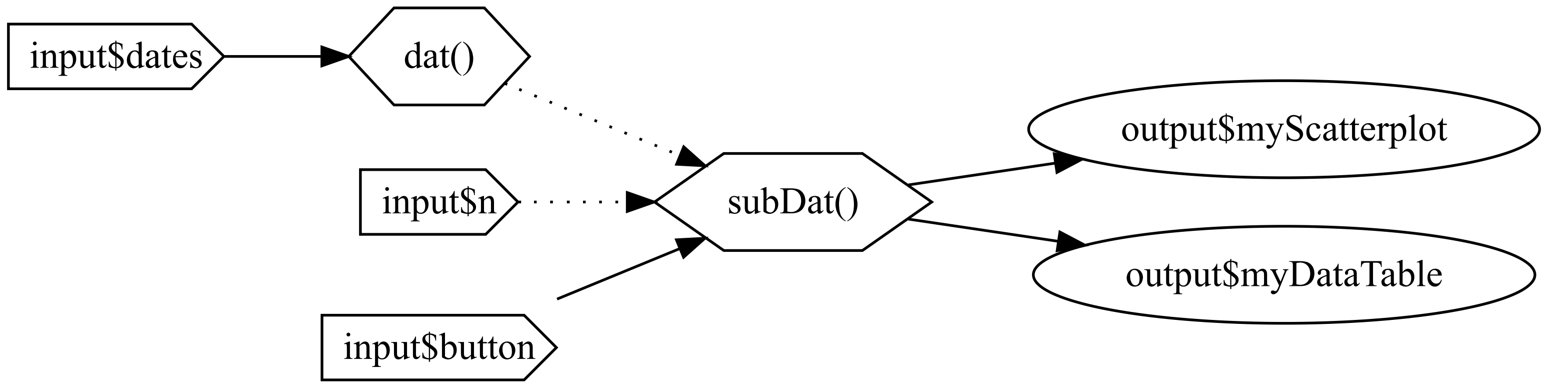
eventReactive and actionButton

- **eventReactive**(eventExpr, valueExpr): delays a reaction
    - `eventExpr` is the input to cause reaction
    - `valueExpr` is the code block to create reactive data
    - Any reactives in `valueExpr` block are **isolated**

```
mydat <- eventReactive(input$x, {
  input$y
  input$z
  return(something)
})
```

- I.e. `input$x` causes `mydat()` to update, the other inputs don't
- Simple application, make `eventExpr` a button!

Visually

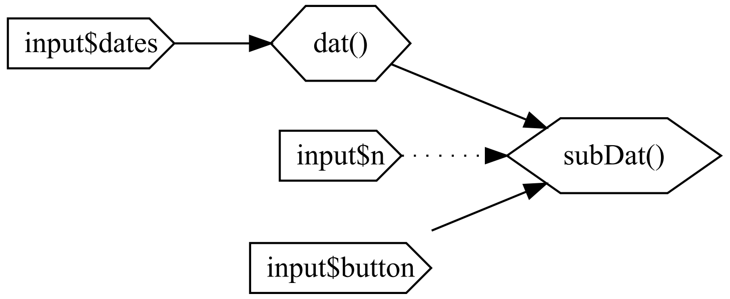


- An updated `input$n` or `dat()` does **not** invalidate `subDat()`
  - Both `input$n` and `dat()` are isolated.
- Clicking `input$button` **does** invalidate `subDat()`

Alternative reactivity

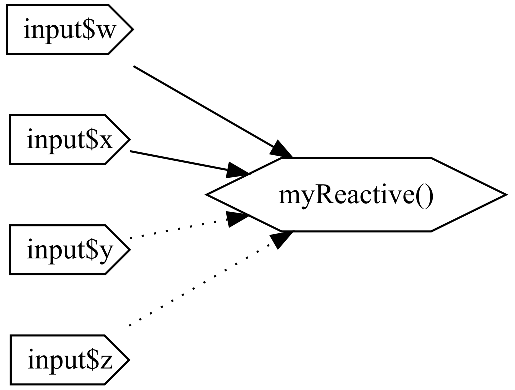
- Suppose you want it to update if either `dat()` or `input$n` updates
  - But **not** when the slider is moved.
- Use a `reactive` with an `isolate` command.

```
subDat <- reactive({
    input$sampButton
    dat() %>% sample_n(isolate(input$n))
  })
```



Finer control reactions

- An `eventReactive` will re-run, **every** time the **first** argument changes.
- A `reactive` will re-run code, **every** time **any** of the input it depends on change.
  - An `isolate` can be used in a reactive to specify which reactions are needed



```r
myReactive <- reactive({
  input$w
  input$x
  isolate({
    input$y
    input$z
    return(<something depending on w, x, y and
  })
})
```

Observers and observeEvent

- Observers **don't** return values in `R`
    - Can't call an observer
- Useful for making *side effects*
    - E.g. updating the UI.
    - Sending messages to console.
    - Saving data to file
    - plot something

General observer

- Runs code when input(s)/reactive(s) change

```
observe({
  input$x
  input$y
  <run this code>
})
```

observeEvent

- observer equivalent of eventReactive!
- observeEvent(eventExpr, handlerExpr)
    - Runs `handlerExpr` code when `eventExpr` updates
- Useful combo, create a save data file button!

```r
observeEvent(input$saveButton, {
  # Something that does a side-effect
})
```

Observers vs reactive

	reactive()	observe()	function()
Callable	Yes	No	Yes
Returns values	Yes	No	Yes
Side effects	No	Yes	Optional
Evaluation	Lazy	Eager	Lazy

- Lazy evalution guide at Hadley's Advanced R