Building Web-enabled Visual Analytics Applications with Shiny: Shiny basic

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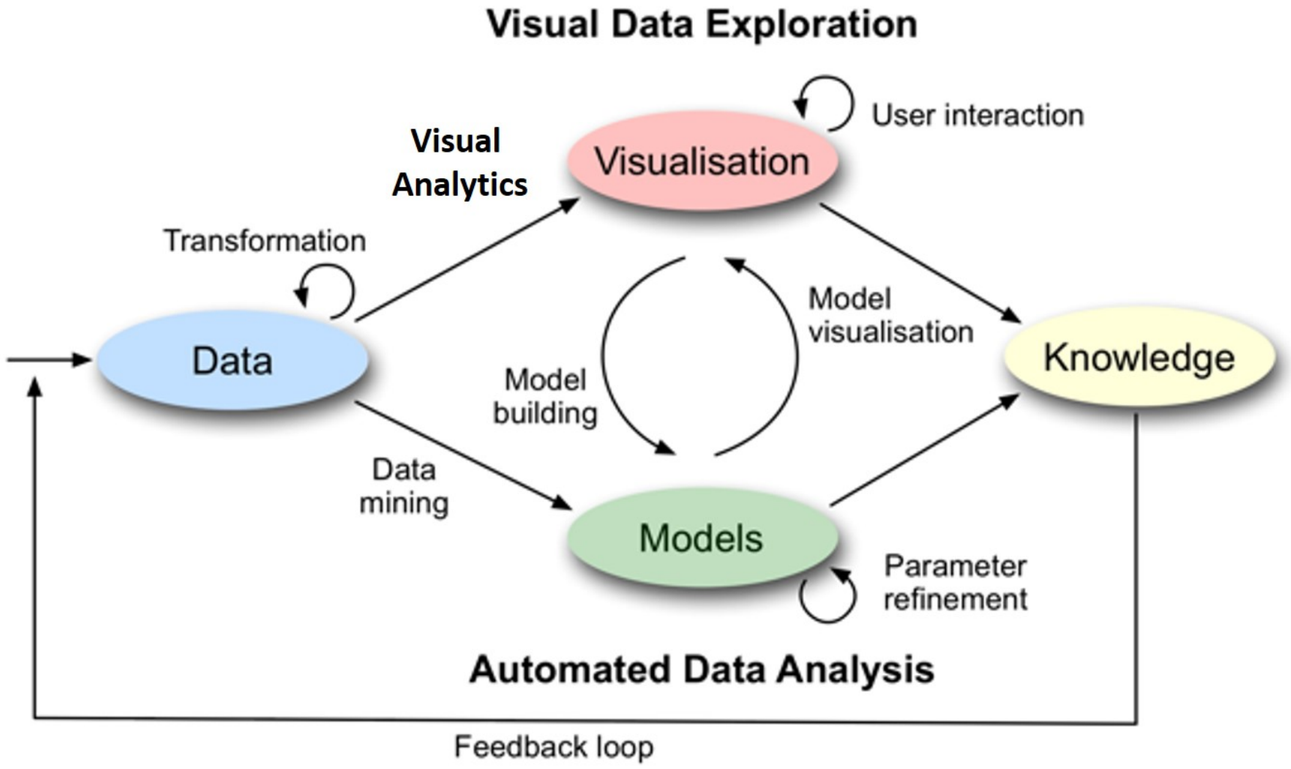
Content

- What is a Web-enabled Visual Analytics Application?
- Why building Web-enabled Visual Analytical Application?
- Evolution of web-based Technology
- Getting to Know Shiny

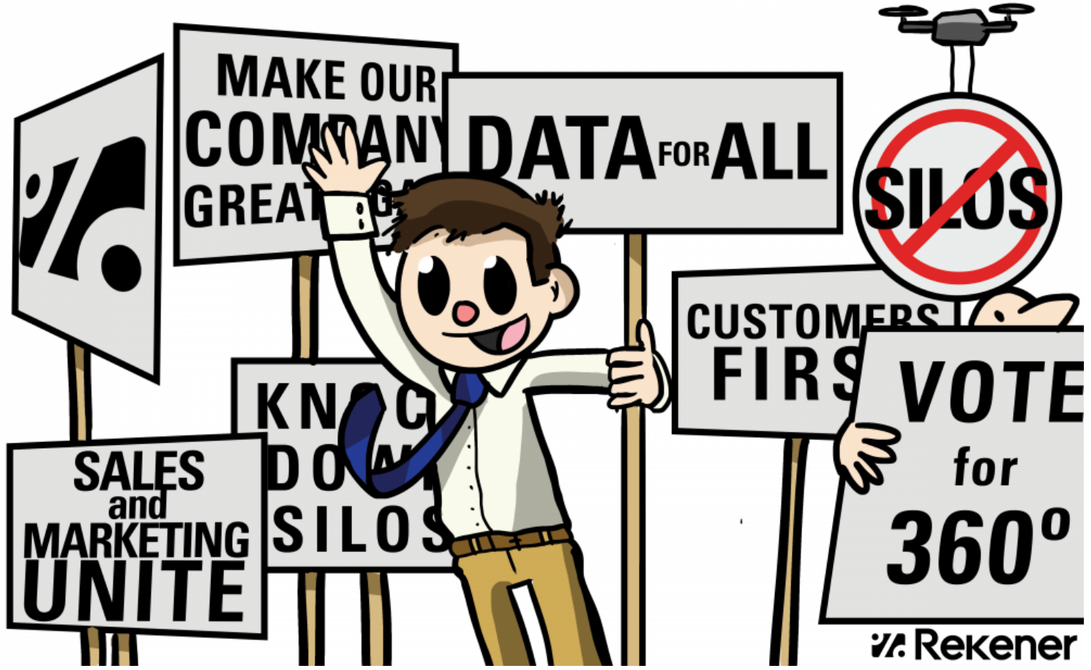
What is a Web-enabled Visual Analytics Application?

- Focuses and emphasises on **interactivity** and effective integration of techniques from **data analytics, visualization and human-computer interaction (HCI)**.



Why building a Web-enabled Visual Analytics Application?

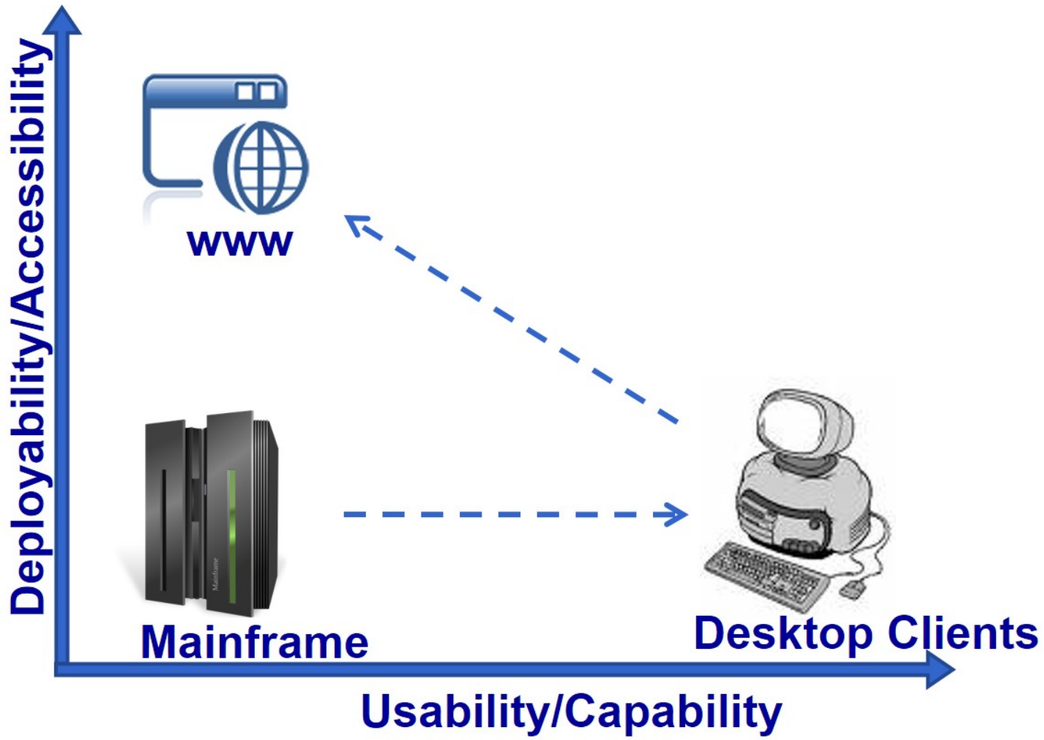
- To explore how the best of these different but related domains can be combined such that **the sum is greater than the parts**.
- To **democratise data and analytics** through web-based analytical applications for data exploration, visualisation analysis and modelling.



Source: Democratize data analytics customer data platform

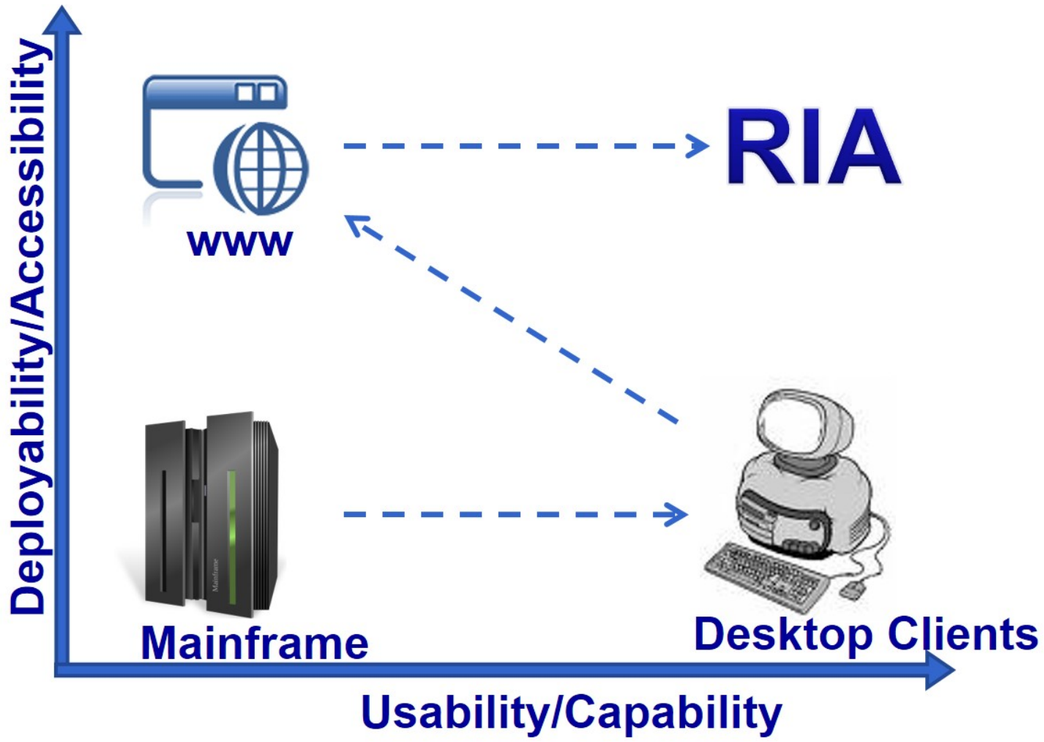
Technology Challenges

- Mainframe computing tend to have low usability and low accessibility.
- Desktop computing tend to have high usability but low accessibility.
- Web-based computing (including mobile computing) are highly accesible but with relatively low capability.



Web-based data visualisation

- The break-through is Rich Internet Applications (RIA)



Reference: Rich Internet Applications

Development of RIA

First generation RIA data visualisation (2000~)

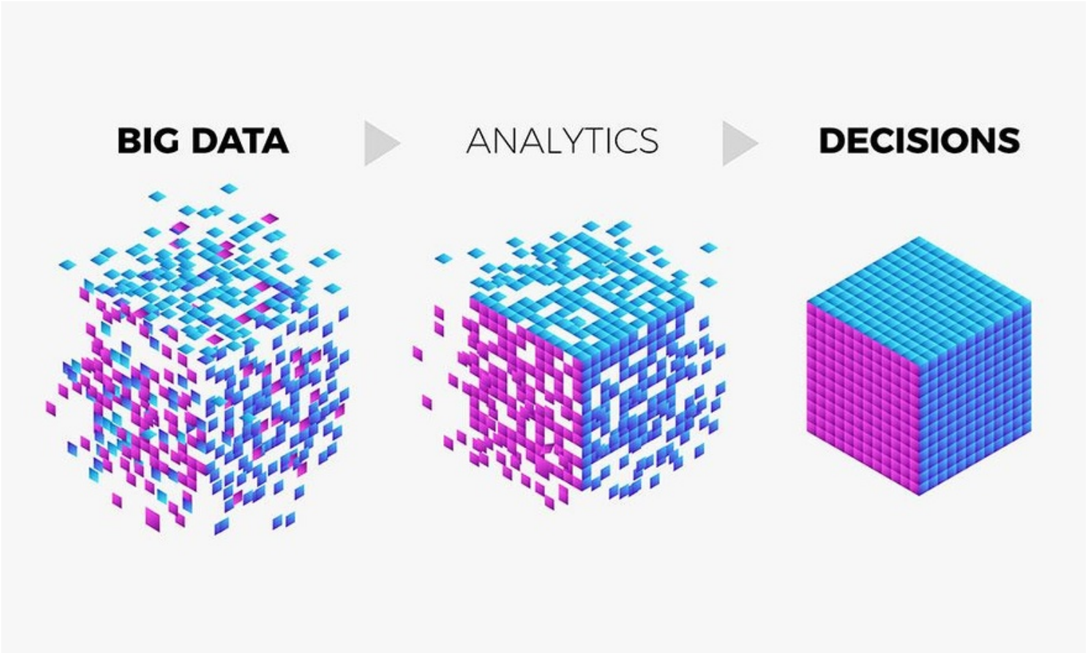
- Adobe Flex Builder
  - Flare
- Microsoft Silverlight
- JavaFX

Second generation RIA data visualisation (2010~)

- HTML 5 + JavaScript + SVG + CSS
  - Client-side rendering
  - No plug-in is required
  - Mobile computing enabled
- D3.js - Data Driven Document

Methodological Challenges

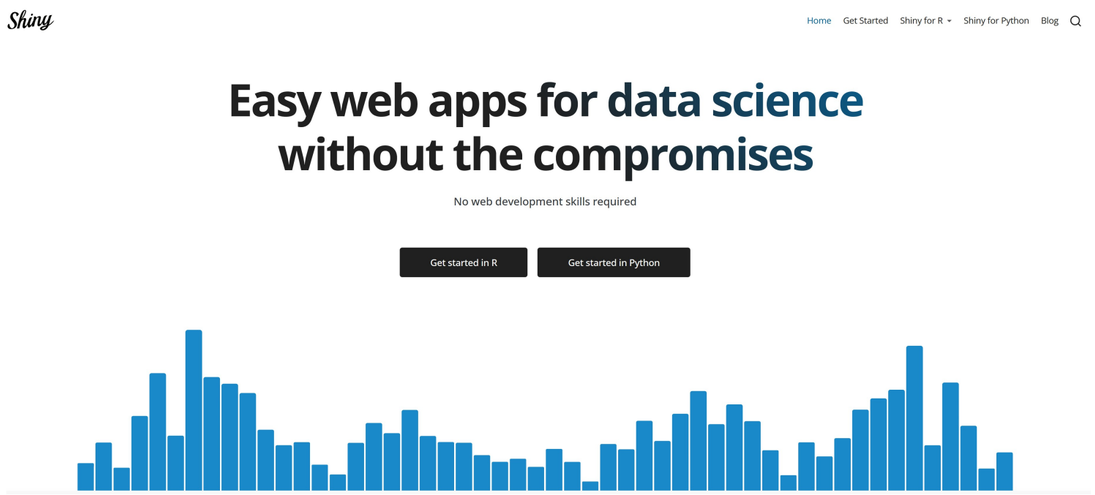
- Lack of analysis functions.
- Not reproducible.
- Not extendable.
- Require to learn multiple technologies and methods.



Getting to Know Shiny

Shiny: Overview

- Shiny is an open source package from Posit (formally called RStudio).
- It provides a **web application framework** to create interactive web applications (visualization) called “Shiny apps”.
- To learn more about Shiny, visit its homepage



Getting to Know Shiny

What is so special about Shiny?

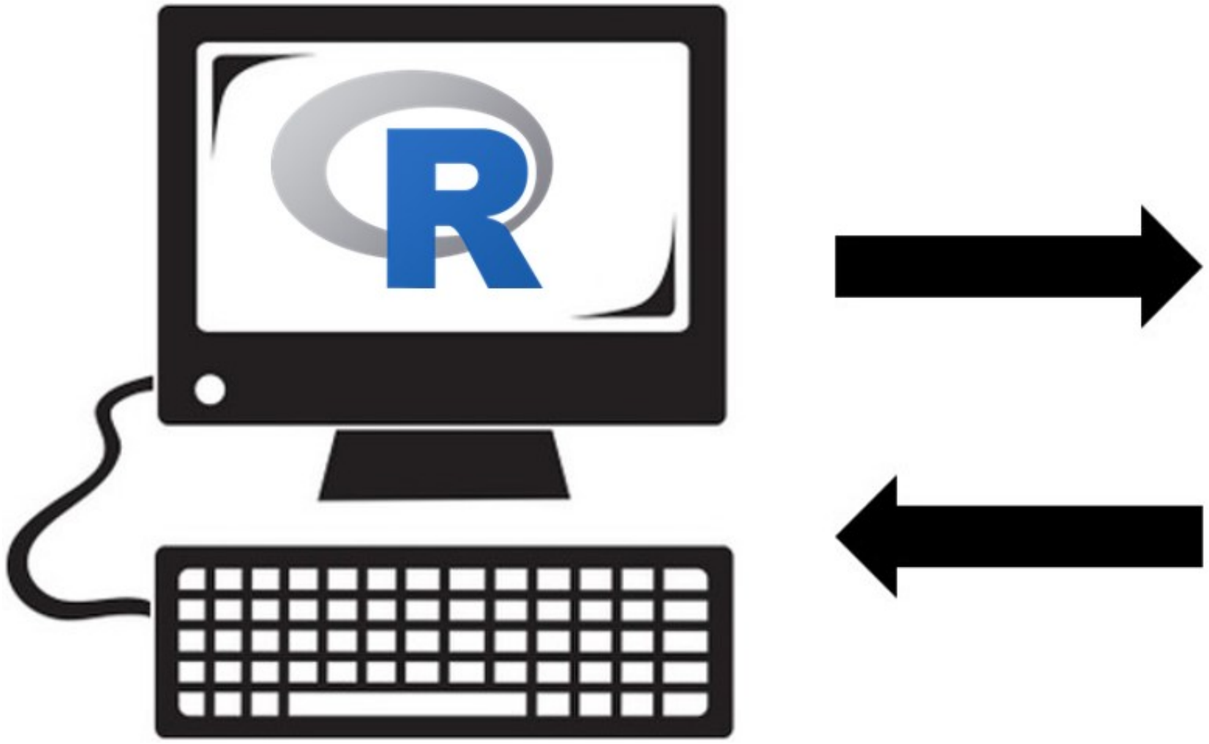
It allows R users:

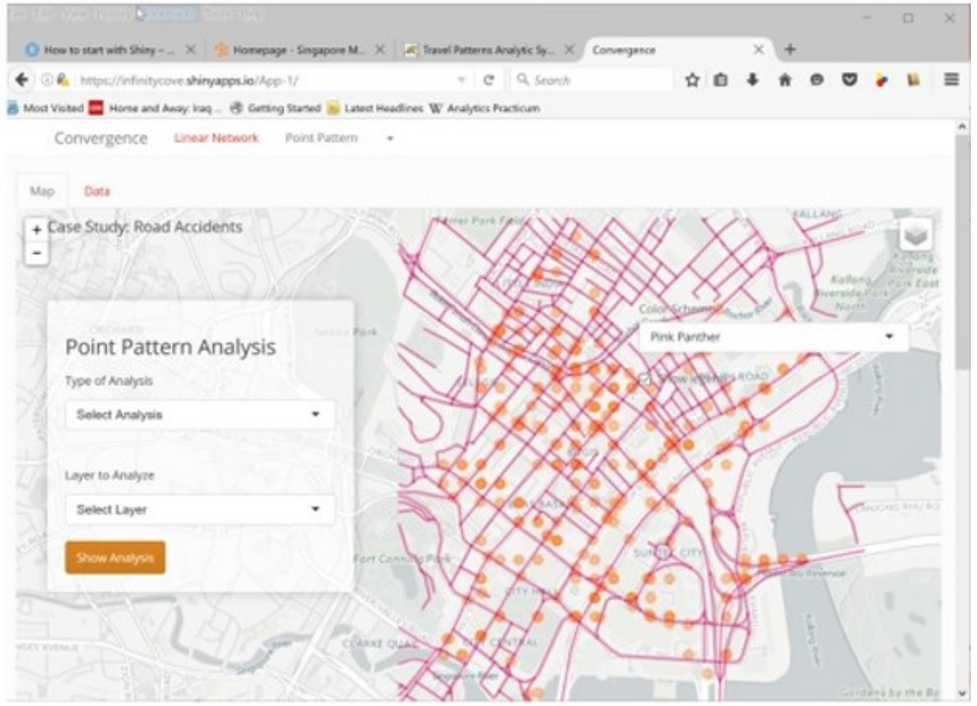
- to build and share highly interactive web-enabled applications without having to invest significant among of time and efforts to master core web design technologies such as html5, Javascript and CSS.
- to integrate the analytical and visualisation packages of R without having to change from one programming language to another.

Getting to Know Shiny

Understanding the architecture

- Every Shiny app is maintained by a computer running R.

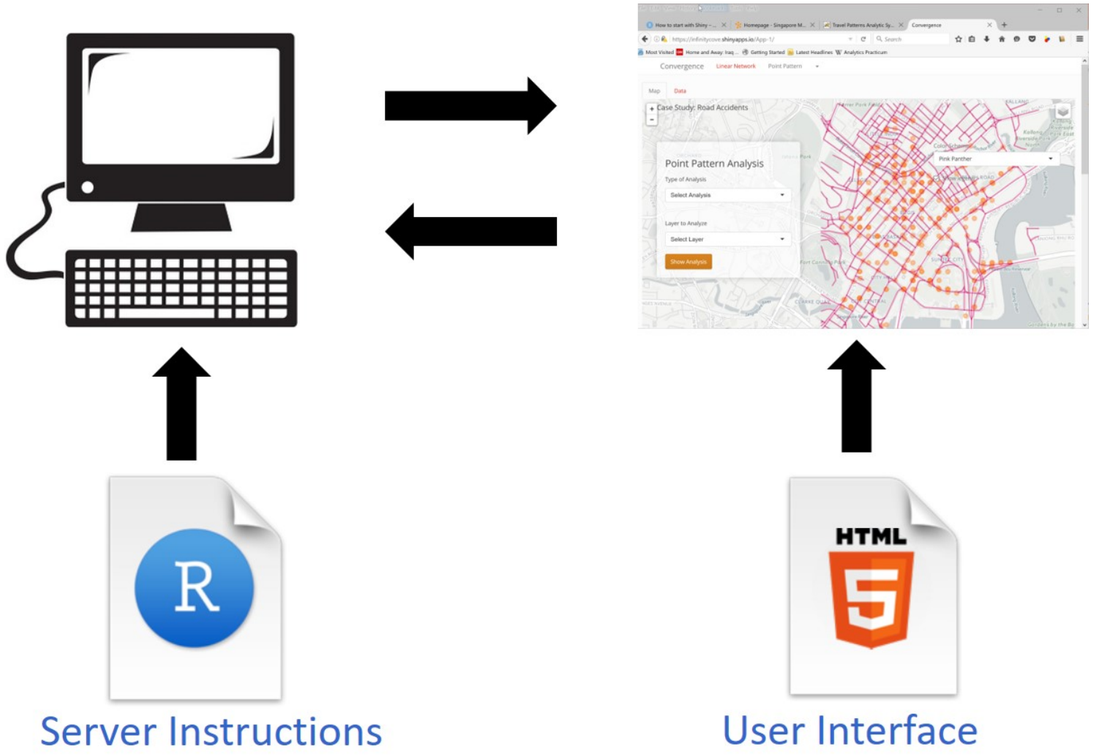




Getting to Know Shiny

The Structure of a Shiny app

- A Shiny app comprises of two components, namely:
  - a user-interface script, and
  - a server script.



Getting to Know Shiny

Shiny's user-interface, *ui.R*

- The *ui.R* script controls the layout and appearance of a shiny app.
  - It is defined in a source script name *ui.R*.
  - Actually, *ui* is a web document that the user gets to see, it is based on the famous Twitter bootstrap framework, which makes the look and layout highly customizable and fully responsive.
  - In fact, you only need to know R and how to use the shiny package to build a pretty web application. Also, a little knowledge of HTML, CSS, and JavaScript may help.

Getting to Know Shiny

Shiny's server *server.R*

- The *server.R* script contains the instructions that your computer needs to build your Shiny app.
- You are expected to:
  - know how to programme with R.
  - familiar with Tidyverse, specifically dplyr, tidyr and ggplot2

Getting to Know Shiny

Shiny Examples

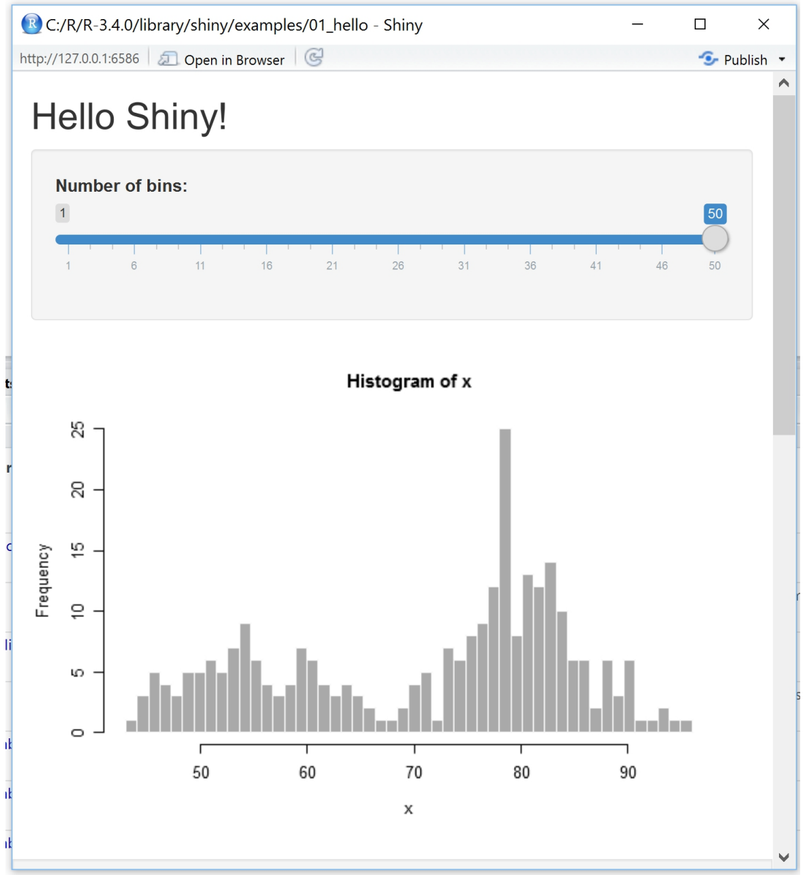
The Shiny package has eleven built-in examples that each demonstrates how Shiny works.

```
runExample("01_hello") # a histogram
runExample("02_text") # tables and data frames
runExample("03_reactivity") # a reactive expression
runExample("04_mpg") # global variables
runExample("05_sliders") # slider bars
runExample("06_tabsets") # tabbed panels
runExample("07_widgets") # help text and submit buttons
runExample("08_html") # Shiny app built from HTML
runExample("09_upload") # file upload wizard
runExample("10_download") # file download wizard
runExample("11_timer") # an automated timer
```

Getting to Know Shiny

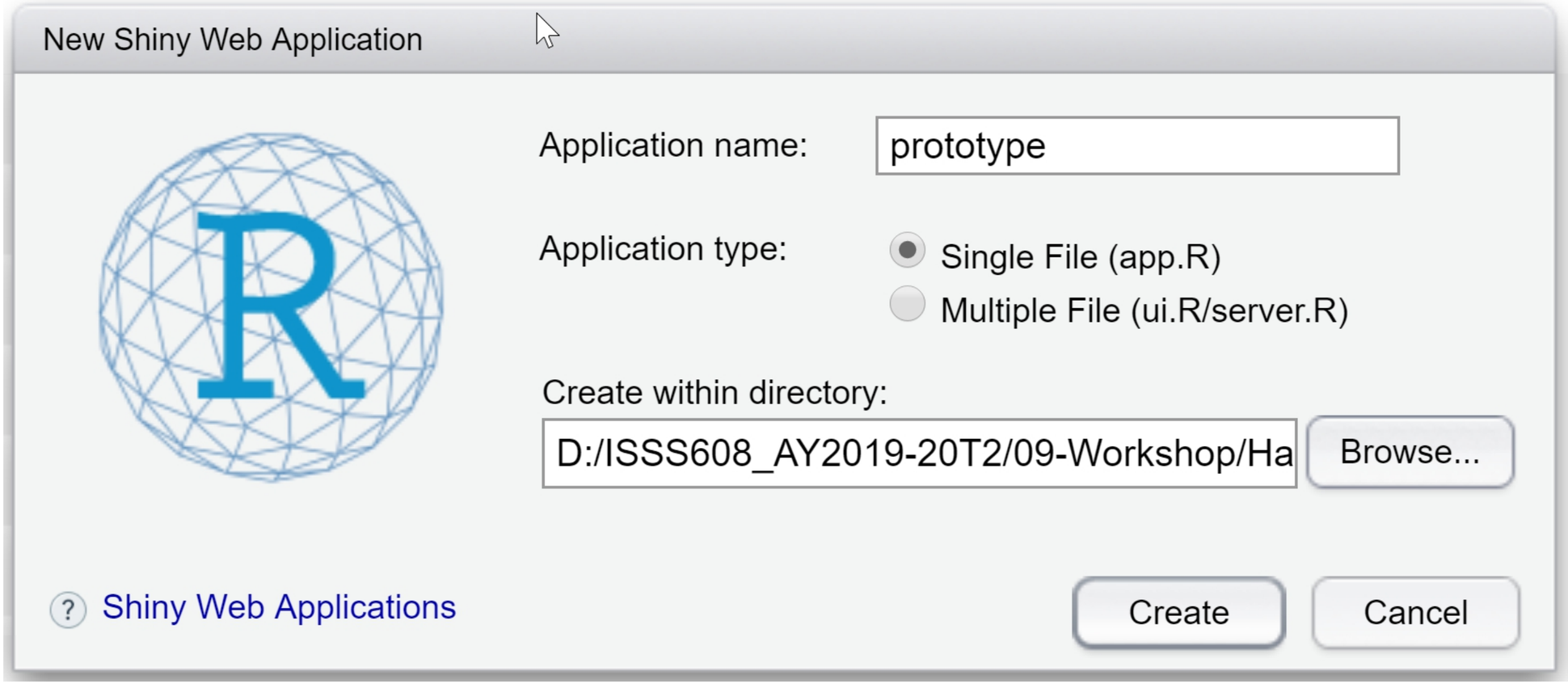
Running Shiny example

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



Building a Shiny app

- A Shiny app can be in a form of a single file called ***app.R***.
- Alternatively, a Shiny app can be also created using separate ***ui.R*** and ***server.R*** files.
- The seperate files way is preferred when the app is complex and involves more codes.



A basic Shiny app script

```
library(shiny)
ui <- fluidPage()

server <- function(input, output) {}

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

User interface
controls the layout and appearance of app

Server function
contains instructions needed to build app

shinyApp()
Creates the Shiny app object

Important tips of Shiny app file

Tip

- It is very important that the name of the file is *app.R*, otherwise it would not be recognized as a Shiny app.
- You should not have any R code after the `shinyApp(ui = ui, server = server)` line. That line needs to be the last line in your file.
- It is good practice to place this app in its own folder, and not in a folder that already has other R scripts or files, unless those other files are used by your app.

Loading the dataset

```
1 library(shiny)
2 library(tidyverse)
3
4 exam <- read_csv("data/Exam_data.csv")
5
6 ui <- fluidPage()
7 server <- function(input, output) {}
8 shinyApp (ui=ui, server=server)
```

- Make sure that the data file path and file name are correct.
- To check if the dataset has been added correctly, you can add a `print()` argument after reading the data.

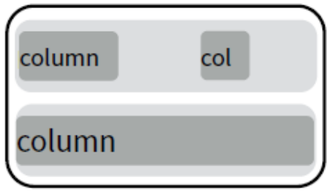
Shiny Layout

- Shiny ui.R scripts use the function *fluidPage* to create a display that automatically adjusts to the dimensions of your user's browser window.
- You lay out your app by placing elements in the fluidPage function.
- *titlePanel* and *sidebarLayout* are the two most popular elements to add to fluidPage. They create a basic Shiny app with a sidebar.

Shiny Layout Panels

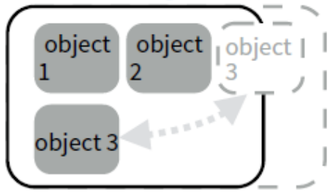
- Panels are used to group multiple elements into a single element that has its own properties.
- Especially important and useful for complex apps with a large number of inputs and outputs such that it might not be clear to the user where to get started.

fluidRow()



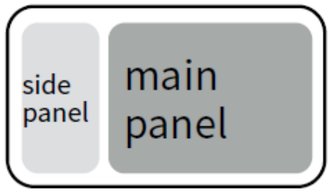

```
ui <- fluidPage(
  fluidRow(column(width = 4),
    column(width = 2,  offset = 3)),
  fluidRow(column(width = 12))
)
```

flowLayout()



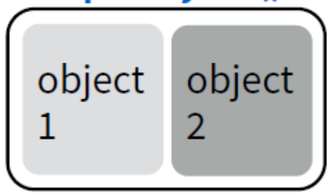

```
ui <- fluidPage(
  flowLayout( # object 1,
              # object 2,
              # object 3
  )
)
```

sidebarLayout()



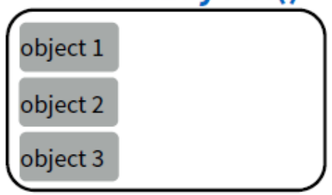

```
ui <- fluidPage(
  sidebarLayout(
    sidebarPanel(),
    mainPanel()
  )
)
```

splitLayout()




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

verticalLayout()

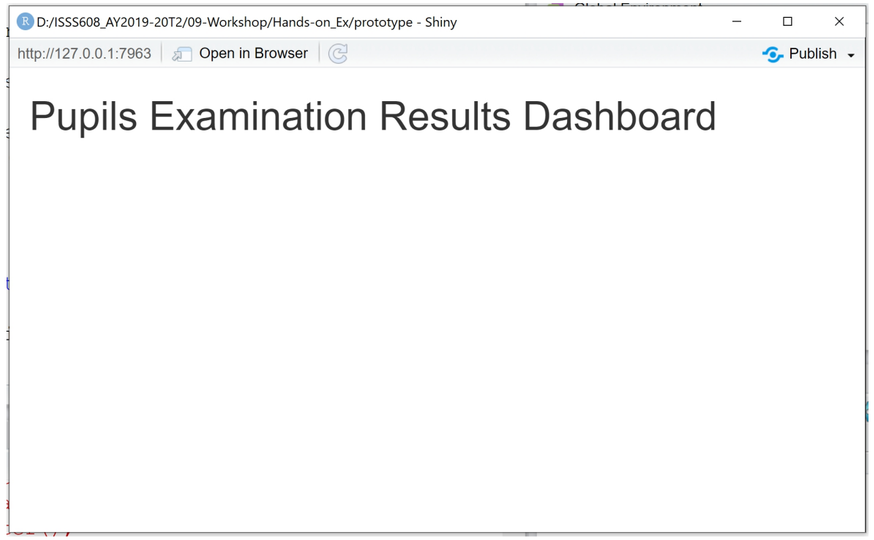



```
ui <- fluidPage(
  verticalLayout( # object 1,
                  # object 2,
                  # object 3
  )
)
```

Working with `titlePanel`

- `titlePanel()` is used to add the application title.

```
1  library(shiny)
2  library(tidyverse)
3
4  exam <- read_csv("data/Exam_data.csv")
5
6  ui <- fluidPage( #<<
7    titlePanel("Pupils Examination Results Dashboard") #<<
8  ) #<<
9
10 server <- function(input, output) {}
11
12 shinyApp (ui=ui, server=server)
```



Shiny Layout Panel : `sidebarLayout()`

- `sidebarLayout()` always takes two arguments:
  - `sidebarPanel()` function output
  - `mainPanel()` function output
- These functions place content in either the sidebar or the main panels.
- The `sidebarPanel()` will appear on the left side of your app by default. You can move it to the right side by giving `sidebarLayout()` the optional argument position = “right”.

```
library(shiny)

# Define UI with default width sidebar
ui <- fluidPage(
  sidebarLayout(
    sidebarPanel("Usually inputs go here"),
    mainPanel("Usually outputs go here")
  )
)

# Define server fn that does nothing :)
server <- function(input, output) {}

# Create the app object
shinyApp(ui = ui, server = server)
```

Hands-on Exercise: Working with `sidebarLayout()`

Lets add the highlighted codes into the original code chunk.

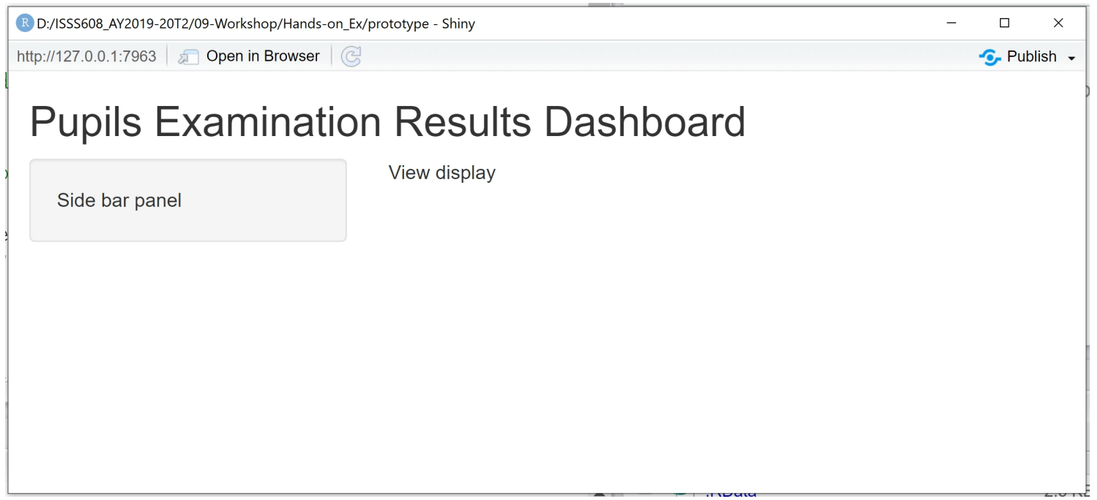
```
library(shiny)
library(tidyverse)

exam <- read_csv("data/Exam_data.csv")

ui <- fluidPage(
  titlePanel("Pupils Examination Results Dashboard"),
  sidebarLayout(
    sidebarPanel("Side bar panel"),
    mainPanel("View display")
  )
)

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

Refresh Shiny App and your screen should look similar to the figure below.



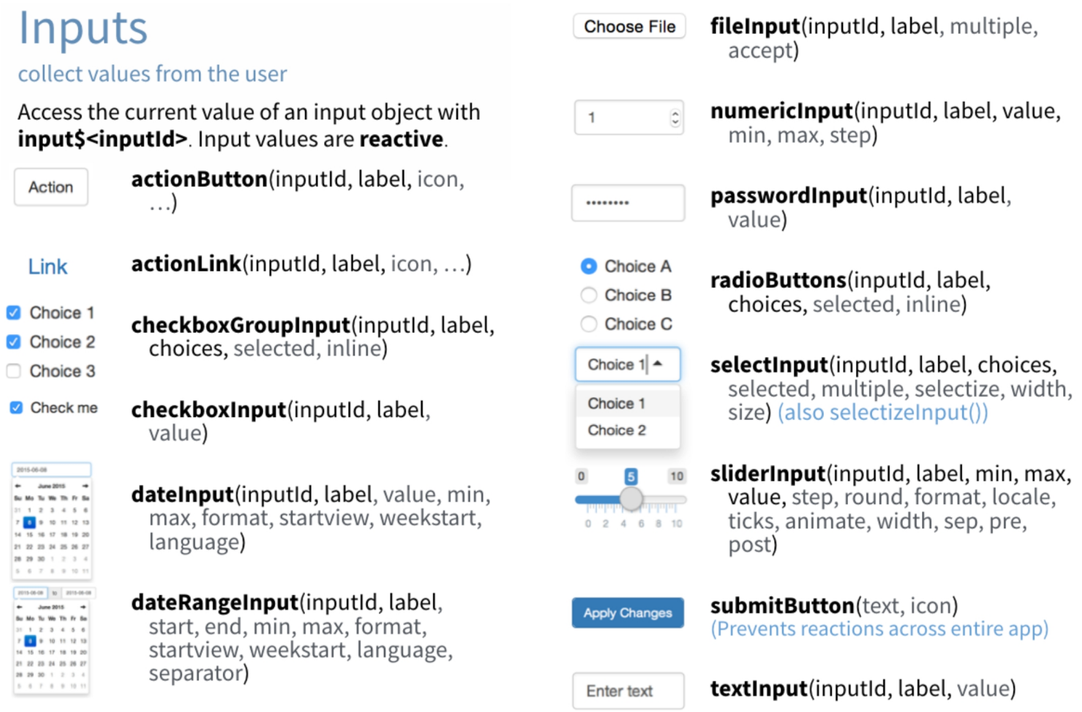
Note

Note that in a fluid design your sidebar and other elements may “collapse” if your browser view is not wide enough.

Shiny Inputs

An overview of Shiny Inputs

- Inputs are what gives users a way to interact with a Shiny app.
- Shiny provides many input functions to support many kinds of interactions that the user could have with an app.

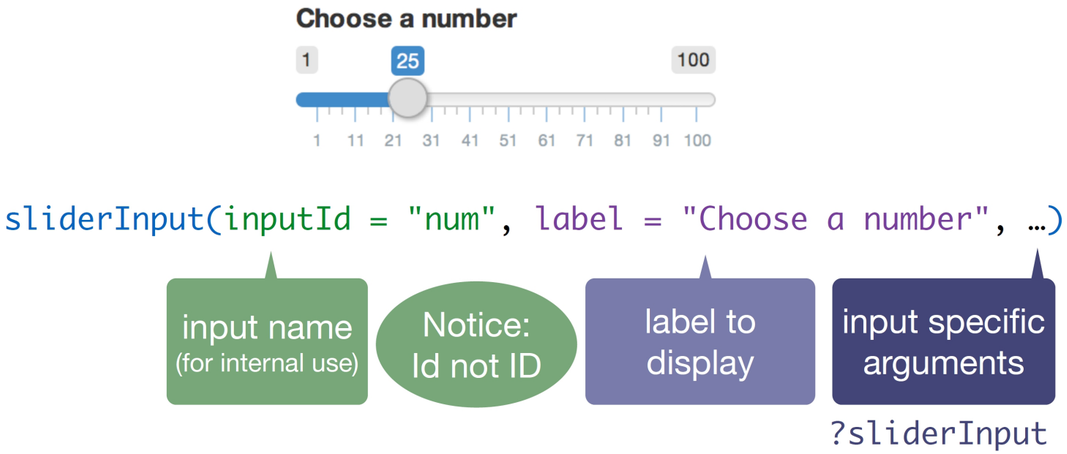


Reference: Refer to 2 Basic UI of Master Shiny to learn more about Shiny UI usage and arguments.

Shiny Inputs

Inputs syntax

- All input functions have the same first two arguments: inputId and label.
- The inputId will be the name that Shiny will use to refer to this input when you want to retrieve its current value.
- It is important to note that every input must have a unique inputId.
- The label argument specifies the text in the display label that goes along with the input widget.
- Every input can also have multiple other arguments specific to that input type.



Hands-on Exercise: Adding inputs

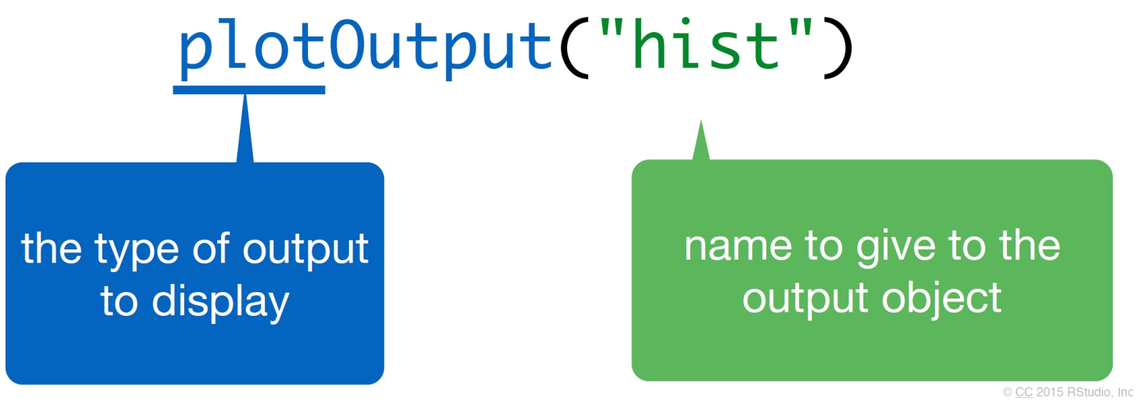
Adding inputs to the UI by using `selectInput()` and `sliderInput()`.

```
ui <- fluidPage(
  titlePanel("Pupils Examination Results Dashboard"),
  sidebarLayout(
    sidebarPanel(
      selectInput(inputId = "variable",
                  label = "Subject:",
                  choices = c("English" = "ENGLISH",
                              "Maths" = "MATHS",
                              "Science" = "SCIENCE"),
                  selected = "ENGLISH"),
      sliderInput(inputId = "bins",
                  label = "Number of Bins",
                  min = 5,
                  max = 20,
                  value= 10)
                ),
    mainPanel()
```

Shiny `Output()`

An overview of Shiny `Output()`

- After creating all the inputs, we should add elements to the UI to display the outputs.
- To display output, add it to `fluidPage()` with an `Output()` function.



Note

- Similarly to the input functions, all the output functions have a outputId argument that is used to identify each output, and this argument must be unique for each output.
- Each output needs to be constructed in the server code later.

Shiny `Output()`

Shiny `Output()` options

- Outputs can be any object that R creates and that we want to display in our app - such as a plot, a table, or text.

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

Hands-on Exercise:

Adding `plotOutput()`

```
ui <- fluidPage(
    titlePanel("Pupils Examination Results Dashboard"),
    sidebarLayout(
        sidebarPanel("Side bar panel"),
        mainPanel(
            plotOutput("distPlot")
        )
    )
)
```

Shiny server.R

Building an output

There are three rules to build an output in Shiny, they are:

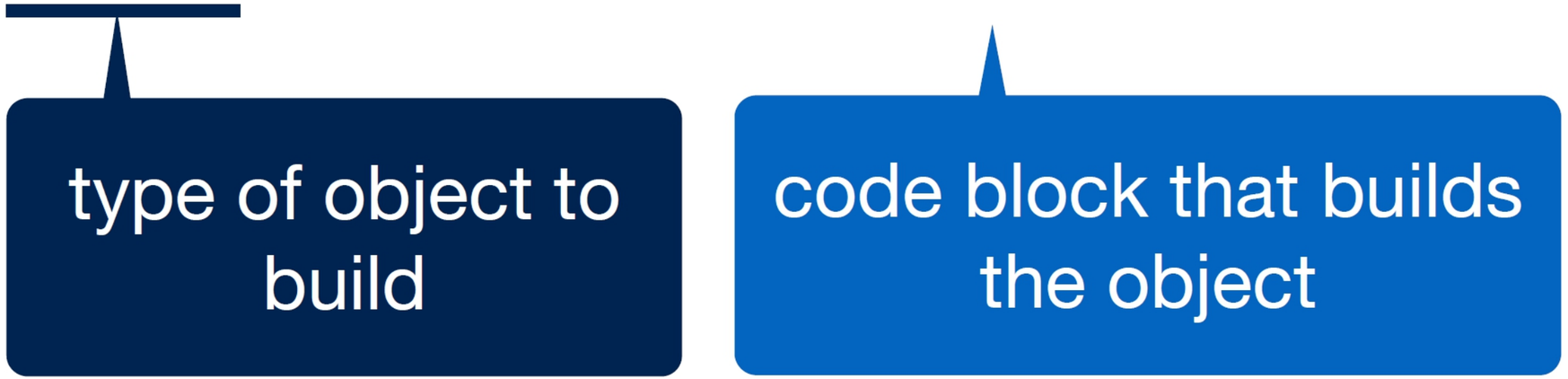
- Save the output object into the output list (remember the app template - every server function has an output argument).
- Build the object with a `render()` function, where is the type of output.
- Access input values using the input list (every server function has an input argument)

> **Note**
>
> The third rule is only required if you want your output to depend on some input.

Shiny server.R

A generic Shiny `render()` syntax

```
renderPlot({ hist(rnorm(100)) })
```

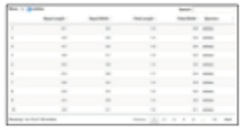


Shiny server.R

Shiny `render()`

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

works with

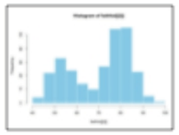


DT::**renderDataTable**(expr, options, callback, escape, env, quoted)

dataTableOutput(outputId, icon, …)

renderImage(expr, env, quoted, deleteFile)

imageOutput(outputId, width, height, click, dblclick, hover, hoverDelay, inline, hoverDelayType, brush, clickId, hoverId)

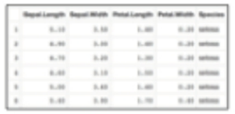


renderPlot(expr, width, height, res, …, env, quoted, func)

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, …)

Hands-on Exercise: Building a basic output

Let's first see how to build a very basic output using `renderPlot()`. We'll create a plot and send it to the ***distPlot*** output.

```
server <- function(input, output){
    output$distPlot <- renderPlot({
        ggplot(exam, aes(ENGLISH)) +
            geom_histogram(bins = 20,
                           color="black",
                           fill="light blue")
    })
}
```

Note

- This simple code shows the first two rules: we're creating a plot inside the `renderPlot()` function, and assigning it to ***distPlot*** in the output list.
- Remember that every output created in the UI must have a unique ID, now we see why. In order to attach an R object to an output with ID x, we assign the R object to ***output$distPlot***.
- Since ***distPlot*** was defined as a ***plotOutput***, we must use the `renderPlot()` function, and we must create a plot inside the `renderPlot()` function.

Hands-on Exercise: Building a basic output

First revision.

```
server <- function(input, output){
    output$distPlot <- renderPlot({
        x <- unlist(exam[,input$variable])
        ggplot(exam, aes(x)) +
            geom_histogram(bins = input$bin,
                           color="black",
                           fill="light blue")
    })
}
```

Hands-on Exercise: Building a basic output

Using `aes_string()`.

```
server <- function(input, output){
    output$distPlot <- renderPlot({
      ggplot(exam,
             aes_string(x = input$variable)) +
        geom_histogram(bins = input$bin,
                       color="black",
                       fill="light blue")
      })
}
```

Note

- Notice that `aes_string()` instead of `aes()` of ggplot2 is used. To understand the differences between `aes_string()` and `aes()`, please refer to this link.

The shinyApp()

> **Important**
>
> - It is important to add *shinyApp()* at the end of your Shiny application.

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

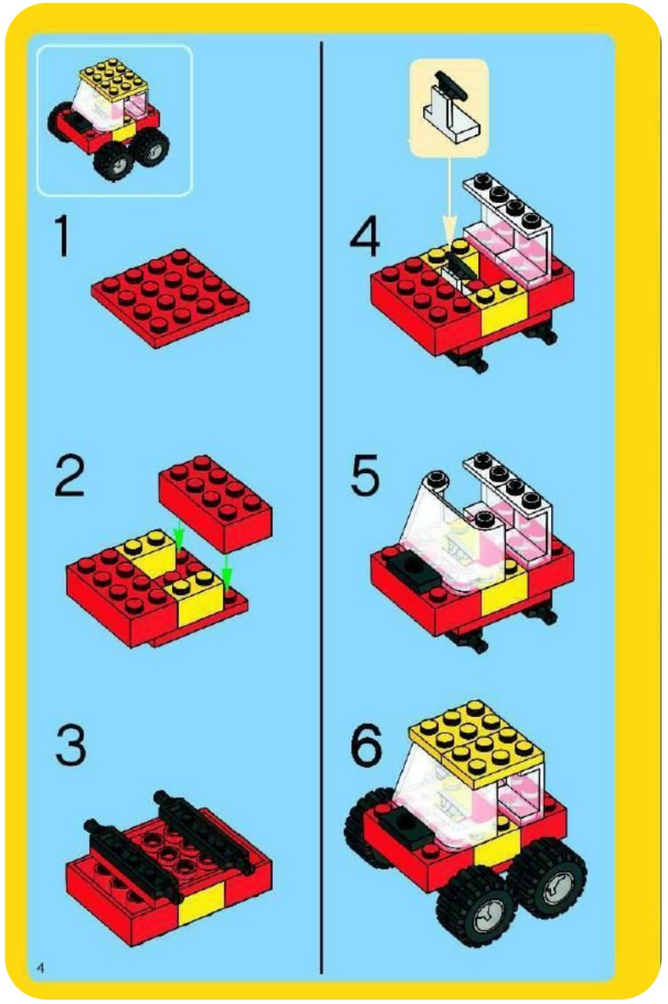
Programming Shiny: Survival Tip!

Tip

- Always run the entire script, not just up to the point where you're developing code.
- Sometimes the best way to see what's wrong is to run the app and review the error.
- Watch out for commas!

Building Shiny Application: Survival Tip!

What can we learn from Lego?



- Sketch the storyboard
- Building the app incrementally
  - Using prototyping approach
  - Start as simple as possible
  - Adding features one at a time
- Save -> Run App

References

- Hadley Wickham (2021) **Mastering Shiny**, O'Reilly Media. This is a highly recommended book.
- Building Web Applications with Shiny, especially Module 1 and 2.
- Shiny Three Parts Tutorial.
- Online Function reference
- The basic parts of a Shiny app
- How to build a Shiny app
- The Shiny Cheat sheet

Beyond Uncle Google! Last but not least, when you need help

- How to get help