Deploying Data Mining Results

Web Applications using Shiny

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Deploying Your Results

- Bringing your results to the users
- Testing on real world environments
- Commercializing your results

Some Potential Difficulties

- Users' lack of knowledge about data mining
- Software requirements for running your results
- Different software environments (e.g. OS, hardware, etc.)
- Maintaining different versions

Some Benefits of Deploying Your Results

- Feedback from real users
- Incorporate feedback - refinement of your solution
- Real world testing

Web Applications

- Applications that runs in a web browser
- Increasingly popular due to:
  - the widespread use of browsers
  - ability to maintain a single version of the software on the server side
  - cross-platform compatibility

Web Applications

- Some Benefits of Web Apps:
  - no complex installation and upgrading processes
  - “no” requirements from the client side (simply a compatible browser)
  - cross-platform compatibility
  - extending to other devices (smartphones, tablets, etc.)
- Some Drawbacks of Web Apps:
  - still some sacrifice to usability
  - eventual connectivity difficulties
  - privacy concerns

R Web Apps using Shiny

- Shiny (http://shiny.rstudio.com) is a web application framework for R
- It has a very intuitive and easy workflow that allows developing web apps very easily
- It allows you to easily deploy your data mining results through a web app
- It is integrated with recent versions of RStudio

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Installing Shiny

- Shiny can be installed as any R package:

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

- It is strongly integrated with the latest versions of RStudio
- Using RStudio will facilitate your task, but it is not mandatory to have web apps in R

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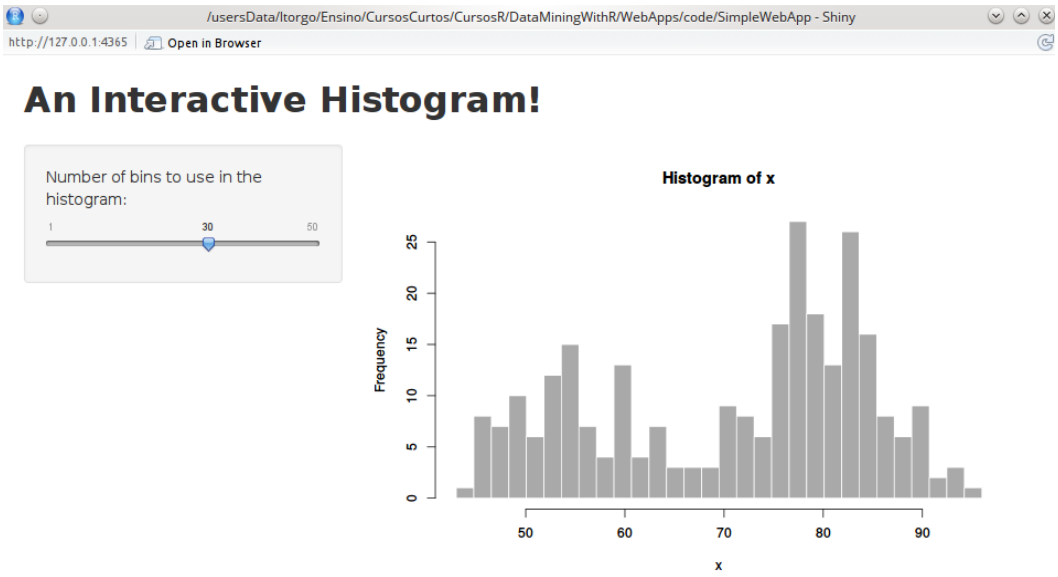
A Simple Illustration

An Interactive Hitogram



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A Simple Illustration

The `ui.R` file

```
library(shiny)
# Define UI for the Web App
shinyUI(fluidPage(

  # Application title
  titlePanel("An Interactive Histogram!"),

  # Sidebar with a slider input for the number of

  # bins
  sidebarLayout(
    sidebarPanel(
      sliderInput("bins",
        "Number of bins to use in the histogram:"
        min = 1,
        max = 50,
        value = 30)
    ),

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

The `server.R` file

```
library(shiny)
# Define server logic to draw the histogram
shinyServer(function(input, output) {

  # Expression that generates a histogram. The
  # expression is wrapped in a call to renderPlot
  # to indicate that:
  #  1) It is "reactive" and therefore should be
  #  automatically re-executed when inputs change
  #  2) Its output type is a plot

  output$distPlot <- renderPlot({
    x    <- faithful[, 2]  # Faithful Geyser data
    bins <- seq(min(x), max(x),
                length.out = input$bins + 1)

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

})
```

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The Structure of a Shiny Web App

- It should be contained in a folder that gives the name to the App
- The folder should contain at least two files:
  - `ui.R` that controls the layout and appearence of the App
  - `server.R` that defines the instructions that shiny needs to build the App
- **Note**: you may also create a shiny web app on a single file

The Structure of a Shiny Web App

Single file version

- You may put all code in a single file named `app.R`
- The file should be stored in a folder with the name of the web app
  - It may become cumbersome for large apps
  - It does not make so obvious the separation between user interface and the server side code
- Below a simple template for this approach

```
## The content of the "app.R" file
library(shiny)

## The user interface
ui <- fluidPage()

## The server-side code
srv <- function(input, output) { }

## The app
shinyApp(ui = ui, server = srv)
```

Running a Shiny Web App

- Through the function `runApp()`

```
library(shiny)
runApp("AppFolderName")
```

- Using a specific button at RStudio GUI

Taking a Closer Look at "ui.R"

The `ui.R` file

```
shinyUI(fluidPage(

    titlePanel("App Title"),

    sidebarLayout(

        sidebarPanel(),

        mainPanel()

        )
    )
)
```

- `shinyUI()` contains the user interface
- `fluidPage()` is one type of web page, containing a fluid layout consisting of rows and columns. Fluid pages make sure their content scale in realtime to the browser width
- `titlePanel()` creates a title panel in the page
- `sidebarLayout()` allows you to define a layout with a sidebar and a main area
- `sidebarPanel()` defines the content of the side bar
- `mainPanel()` defines the content of the main panel forming the side bar layout

Taking a Closer Look at "server.R"

The `server.R` file

```
shinyServer(
    function(input, output) {
        output$distPlot <- renderPlot({
              bins <- seq(min(x), max(x), length.out = input$bins + 1)
              hist(x, breaks = bins, col = 'darkgray', border = 'white')
            })
    }
)
```

- `shinyServer()` defines the server-side logic of the App. It is a function that is called the first time the browser loads the page. It must take parameters "input" and "output".
- `output` is a list with as many components as there are output elements in the UI. You define here how the output is generated
- `input` is another list with as many components as there are user interface input elements. You can use this list to get the user inputs to the interface.

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Going Back to the Example

```
# Define UI for the Web App
shinyUI(fluidPage(

  # Application title
  titlePanel("An Interactive Histogram!"),

  # Sidebar with a slider input for the number of

  # bins
  sidebarLayout(
    sidebarPanel(
      sliderInput("bins",
        "Number of bins to use in the histogram:"
        min = 1,
        max = 50,
        value = 30)
    ),

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

```
library(shiny)

# Define server logic to draw the histogram
shinyServer(function(input, output) {

  # Expression that generates a histogram. The
  # expression is wrapped in a call to renderPlot
  # to indicate that:
  #  1) It is "reactive" and therefore should be
  #  automatically re-executed when inputs change
  #  2) Its output type is a plot

  output$distPlot <- renderPlot({
    x    <- faithful[, 2]  # Faithful Geyser data
    bins <- seq(min(x), max(x),
                length.out = input$bins + 1)

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

})
```

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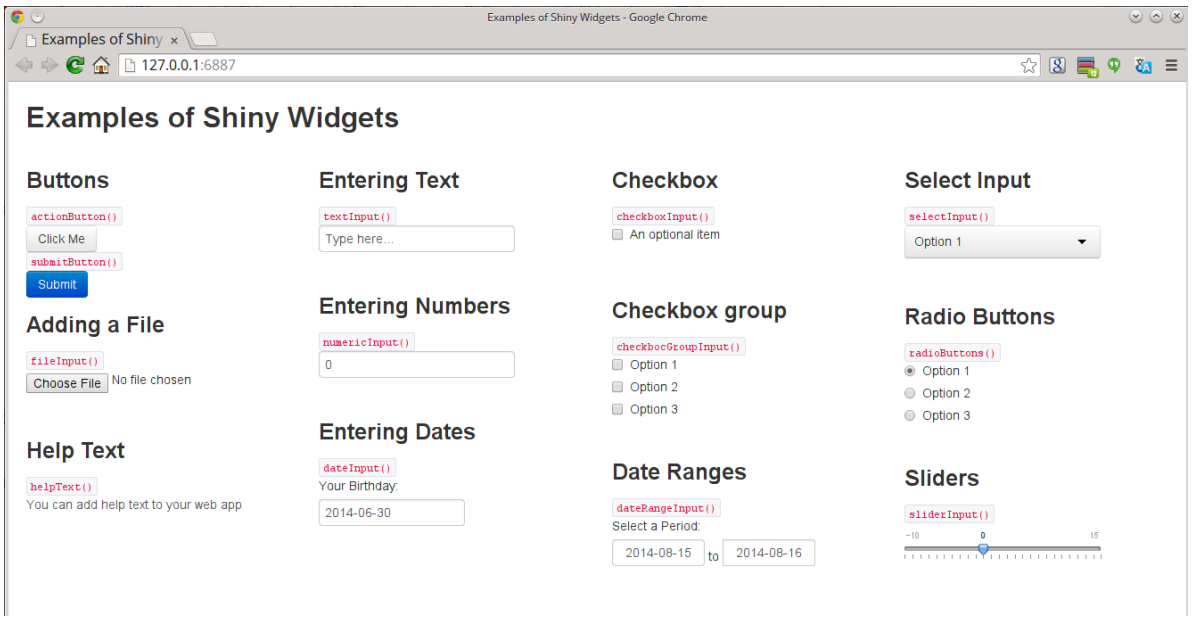
Some Shiny Widgets



Knowing More About Shiny Widgets

Shiny Widgets Gallery
http://shiny.rstudio.com/gallery/

Output Reacting to User Interaction

Reactive output has to do with content in web apps that is dependent on user interaction with the app (through widgets)

Including Reactive Output

- Having reactive output in a page involves two steps:
  1. Include the object content in the page (in “ui.R”)
  2. Tell shiny how to get the object content (in “server.R”)
- If the object content depends on the value of some shiny widget(s) you have reactive output

Output Functions

- Output functions (`*Output()`) tell Shiny where to display the content of an R object in the page
- Examples:
  - `plotOutput()` can be used to include a plot
  - `tableOutput()` can be used to include the contents of a table
  - `textOutput()` can be used to include text
- There are more functions (all following the naming convention `*Output()`)

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Building Content

- In “server.R” you tell Shiny how to build the objects that will be placed in the page
- Examples:
  - Non-reactive content

```
shinyServer(function(input, output) {
     output$textField <- renderText({
          paste("The square of 2 is ",2^2)
     })

  }
)
```

  - The above example assumes that somewhere in “ui.R” there is an output element of the form `textOutput(textField)`

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Building Content (cont.)

- Example with reactive content

```
shinyServer(function(input, output) {
     output$textField <- renderText({
          paste("The square of",input$userNumber,
                "is",input$userNumber^2)
     })

  }
)
```

- Again there should be `textOuput(textField)` in "ui.R", but also a `numericInput()` widget with name "userNumber" that allows the output to be re-active to whatever input the user inserts in this widget

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Functions for Building Content

- Examples:
  - `renderText()` for character strings
  - `renderPlot()` for R plots
  - `renderPrint()` for any printed output
  - `renderTable()` table-like output (data frames, matrices, etc.)
- There are more functions (all following the naming convention `render*()`)

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Widget Values

- The components of the `input` list contain the values of the widgets
- The type of value depends on the widget
- For instance a `dateRangeInput()` will produce a vector with two values, whilst a `numericInput()` widget will produce a single value

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Code Execution

server.R

```
# some code

shinyServer(
   function(input, output) {

      # more code can be here

      output$myPlot <- renderPlot( {

         # yet more code here

      })
   }
)
```

This code is run once when the Web App is launched

Strongly inspired on RStudio Shiny tutorial

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Code Execution - 2

server.R

```
# some code

shinyServer(

   function(input, output) {

      # more code can be here

      output$myPlot <- renderPlot( {

         # yet more code here

      })
   }

)
```

This code is run once when a new user visits the Web App

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Code Execution - 3

server.R

```
# some code

shinyServer(

   function(input, output) {

      # more code can be here

      output$myPlot <- renderPlot( {

         # yet more code here

      })
   }

)
```

This code is run every time the user changes a widget that myPlot depends upon

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Hands on Shiny Web Apps

1. Load the R data set **AirPassengers** and convert it into an `xts` object. Create a web app that allows the user to select the period of time she/he wants to visualize the number of air passengers.
2. Create a web app that allows the user to check the exchange rates between a pre-defined set of currencies. The app should allow the user to: (i) select the currencies; and (ii) select the past time window of rates to visualize. For the second of these requirements the user should be allowed to select among a set of time units (e.g. day, month, year), and also to indicate a number of these units. This means it should be easy to inspect the exchange rates for the last 5 months or 20 days, for instance.

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How to Share your Web Apps with Others?

- There are two ways (both with pros and cons):
  1. Share the R code of your App (e.g. “ui.R” and “server.R”)
  2. Share the App as the URL of a Web page

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Sharing the Code

- You send your user the contents of your Web app folder (preferably zipped)
- Your user opens R and provided it has Shiny installed simply runs:

```
library(shiny)
runApp("yourFolderName")
```

- As an alternative you may host your zip file at some web page you have access and the user runs:

```
library(shiny)
# you may try this one!"
runUrl("http://www.dcc.fc.up.pt/~ltorgo/MSBA/SimpleWebApp.zip")
```

- Other possibilities exist through hosting sites like GitHub and Gist and the functions `runGitHub()` and `runGist()`

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Sharing the Code - pros and cons

- Advantages:
  - Very simple to share - just Zip the folder and you are done
- Disadvantages:
  - Your user needs to have R and the necessary packages installed
  - Your user needs a minimal familiarity with running R and executing commands in R
  - Your app is dependent on the user software environment that you do not control

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Sharing the App as a Web Page

- Your user will not need to know anything about R!
- RStudio currently provides 3 solutions for this:
  1. ShinyApps.io (https://www.shinyapps.io/)
  2. Shiny Server
  3. Shiny Server Pro

ShinyApps.io

- This is a (free for now) Shiny App hosting service from RStudio
- You create an account and then
  1. Install and then load the **rsconnect** R package
  2. Login into ShinyApps.io and configure the `rsconnect` connection obtaining the authorization information you need to run at your R:

```
setAccountInfo(
    name="ltorgo",
    token="<MYTOKEN>",
    secret="<SECRET>")
```

  3. Move into the folder where your app code is and issue in R:

```
library(rsconnect)
deployApp()
```

  4. Your applications will now be available at a URL related with your account

     `https://ltorgo.shinyapps.io/myWebApp`

Shiny Server

- Shiny Server is a program that builds a web server designed to host Shiny apps.
- It's free, open source, and available from Github.
- Shiny Server runs on Linux servers.

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Shiny Server

- You need a Linux server running Ubuntu 12.04 or greater (64 bit) or CentOS/RHEL 5 (64 bit).
- If you are not using one of these Linux distributions, you need to compile it from source.

This solution requires access to a Linux web server and technical support to install the program at this server

Installation instructions at
https://github.com/rstudio/shiny-server/blob/master/README.md

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Shiny Server Pro

- Shiny Server Pro is a paid service to host shiny Apps
- It provides features as:
  - Password authentification
  - SSL support
  - Administrator tools
  - Priority support
  - and more.

More information at
http://www.rstudio.com/products/shiny-server-pro/