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1. Introduction

After working with R in a few courses, and having used base graphics and ggplot2, we wanted to explore the possibilities of interactive visualizations in the shiny package. This is something we think might be relevant later in our careers, as interactive visualizations can give a new dimensionality to reports. Rich reports with interactive visualizations gives the reader the option to dig deeper into the data if needed.

2. Shiny package

How Shiny works. - Web -> javascript, html and css. Easily sharable. ## 2.1

2.1 Elements of a Shiny app

Explain how a Shiny app is made, the elements needed, server/ui files, functions used.

2.2 ggplot2

1.1 Research question

How can interactive visualizations be used . . .

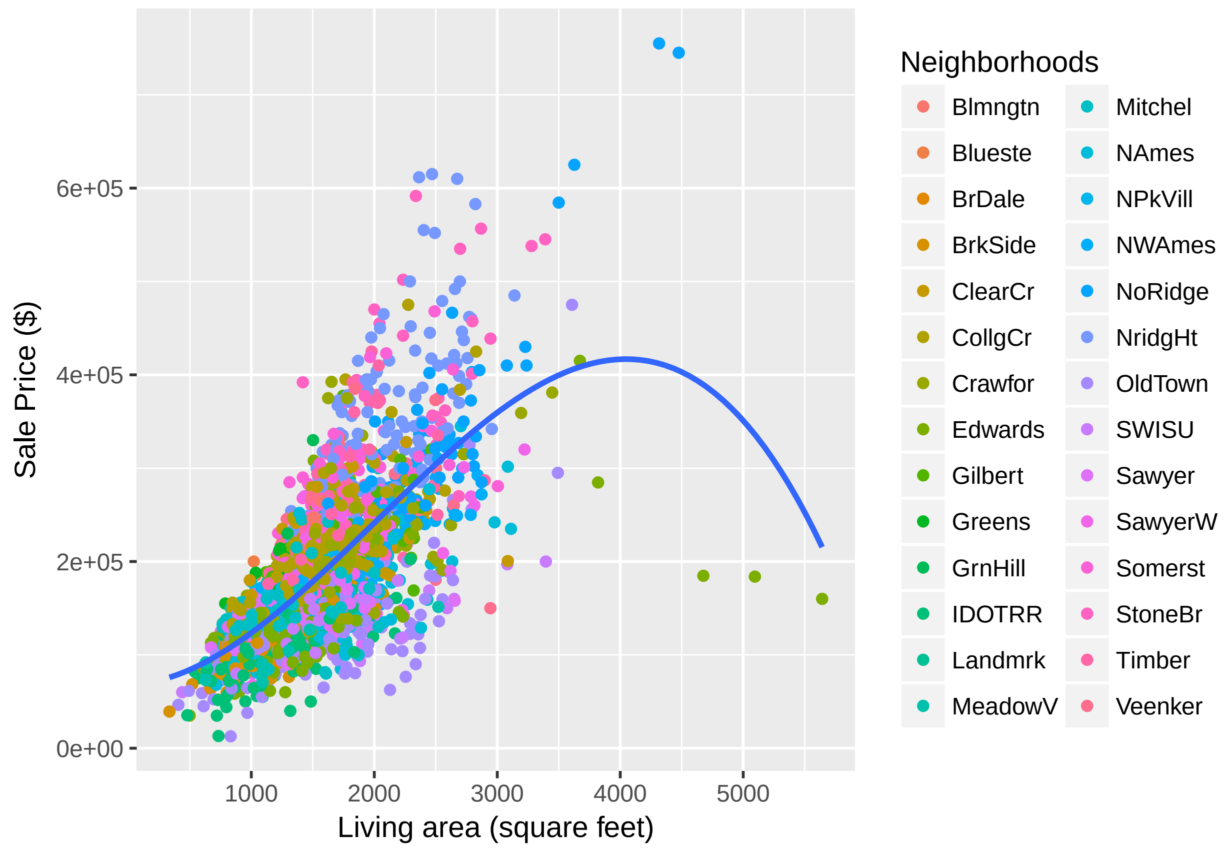
3. Housing prices dashboard

To illustrate how interactive visualizations can fascilitate a deeper dive into the data, we have used the Ames Housing dataset downloaded from the American Statistical Association. The dataset includes data on properties sold in Ames, Iowa. The main plot of the dashboard is a plot of the sales price against the living area of the house.

```r
# Load ggplot2
library(ggplot2)

# Load data
house <- read.csv('houseprices.csv')

ggplot(data = house, aes_string(x = house$GrLivArea, y = house$SalePrice)) +
  geom_point(aes_string(col = house$Neighborhood)) +
  geom_smooth(method = "lm", formula = y ~ splines::bs(x, 3), se = F) +
  labs(x = "Living area (square feet)", y = "Sale Price ($)", col = "Neighborhoods")
```



By looking at the graph, it is easy to see the positive relationship between sales price and the size of the house. However, it is very difficult separate the neighborhoods from each other. In general, this is a plot which tries to give too much information. With static visualizations, too much information in a plot can make it look cluttered, and it is difficult to communicate the data clearly. With interactive visualizations, however, we have more opportunities. The dashboard should be able to filter neighborhoods, and click and drag a selection of observations in the scatter plot to get the raw data. An analyst, real estate agent or housing prices enthusiast would like to have the opportunity to dig deeper into the data.

```
DT::renderDataTable({
  brushedPoints(house, brush = input$plot_brush) %>%
    filter(!(Neighborhood %in% input$neighbourhoods)) %>%
    select(SalePrice, Neighborhood, TotalSF, HouseAge, SaleCondition, GarageCars, GarageAge)
})
```

Moreover, it should be possible to change variables on the x-axis, so the analyst can explore what other factors affects the sales price. The color of the points could also be used for other variables than neighborhoods, for example to separate new houses from old ones. and behind the points. Finally, a slider for the regression line can help in the analysis of the relationship between the variables.

3.1 Code for creating the Shiny app

```
library(shiny)
library(DT)
```

```
##
## Attaching package: 'DT'
## The following objects are masked from 'package:shiny':
##
##     dataTableOutput, renderDataTable
```

```r
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(readr)

# Load data
house <- read.csv('houseprices.csv')

# Get lists of all neighbourhoods and which to exclude by default, for plotting
house$Neighborhood = as.factor(house$Neighborhood) # for levels to be pulled, it needs to be formatted 
all_neighbourhoods <- levels(pull(house, 'Neighborhood'))
exclude_neighbourhoods <- setdiff(levels(house$Neighborhood), c("Blmngtn", "StoneBr", "Mitchel", "OldTo

# Define UI for application
fluidPage(
  # Application title
  titlePanel("Iowa Housing: Sale Price"),

  # Sidebar with various Exploratory Data Analysis choices
  sidebarLayout(
    sidebarPanel(
      # Select variable for x-axis
      selectInput(inputId = "x",
                  label = "X-axis:",
                  choices = c("GrLivArea", "TotalSF", "TotalBsmtSF", "HouseAge"),
                  selected = "GrLivArea"),

      # Select variable for colour
      selectInput(inputId = "z",
                  label = "Colour:",
                  choices = c("Neighborhood", "CentralAir", "MSSubClass", "SaleType", "SaleCondition",
                  selected = "Neighborhood"),

      # Select the number of smoothing splines vs. SalePrice
      sliderInput(inputId = "splines",
                  label = "Smoothing splines:",
                  min = 1, max = 19, step = 2,
                  value = 5),

      # Select which neighbourhoods to exclude from the plot, as it can get cluttered quickly
      selectInput(inputId = "neighbourhoods",
                  label = "Exclude neighbourhoods:",
                   choices = all_neighbourhoods,
                   selected = exclude_neighbourhoods,
                   multiple = TRUE,
                   selectize = TRUE),

      # Place the boxplot on the lower left side
      plotOutput(outputId = "boxPlot")
    ),

    # Show scatter plot and table of selected data on the right side (main area)
    mainPanel(
      plotOutput(outputId = "scatterPlot", brush = "plot_brush"),
      htmlOutput(outputId = "instructions"),
      dataTableOutput(outputId = "houseTable"),
      br()
    )
  )
)

# Define server logic required to draw the plots
function(input, output) {
  output$scatterPlot <- renderPlot({
    ggplot(data = house %>% filter(!(Neighborhood %in% input$neighbourhoods)),
           aes_string(x = input$x, y = "SalePrice")) +
      geom_point(aes_string(col = input$z)) +
      geom_smooth(method = "lm", formula = y ~ splines::bs(x, input$splines), se = F) +
      labs(
        y = "Sale Price ($)"
      )
  })

  output$boxPlot <- renderPlot({
    ggplot(data = house %>% filter(!(Neighborhood %in% input$neighbourhoods))) +
      geom_boxplot(aes_string(x = input$z, y = "SalePrice", fill = input$z)) +
      theme(legend.position="none",
            axis.title.y=element_blank(),
            axis.text.y=element_blank(),
            axis.ticks.y=element_blank()) +
      labs(
        x = ""
      )
  })

  output$instructions <- renderUI({
    HTML("Click and drag selection of observations in scatter plot to inspect closer.<br>")
  })

  # Create data table
  output$houseTable <- DT::renderDataTable({
    brushedPoints(house, brush = input$plot_brush) %>%
      filter(!(Neighborhood %in% input$neighbourhoods)) %>%
      select(SalePrice, Neighborhood, TotalSF, HouseAge, SaleCondition, GarageCars, GarageAge)
  })
```

```
}
```

3.2 The dashboard

```
library(shiny)
library(DT)
library(readr)
library(dplyr)
library(ggplot2)

# Load data
house <- read.csv('houseprices.csv')

# Get lists of all neighbourhoods and which to exclude by default, for plotting
house$Neighborhood = as.factor(house$Neighborhood) # for levels to be pulled, it needs to be formatted
all_neighbourhoods <- levels(pull(house, 'Neighborhood'))
exclude_neighbourhoods <- setdiff(levels(house$Neighborhood), c("Blmngtn", "StoneBr", "Mitchel", "OldTo

# Define UI for application
fluidPage(
  # Application title
  titlePanel("Iowa Housing: Sale Price"),

  # Sidebar with various Exploratory Data Analysis choices
  sidebarLayout(
    sidebarPanel(
      # Select variable for x-axis
      selectInput(inputId = "x",
                  label = "X-axis:",
                  choices = c("GrLivArea", "TotalSF", "TotalBsmtSF", "HouseAge"),
                  selected = "GrLivArea"),

      # Select variable for colour
      selectInput(inputId = "z",
                  label = "Colour:",
                  choices = c("Neighborhood", "CentralAir", "MSSubClass", "SaleType", "SaleCondition",
                  selected = "Neighborhood"),

      # Select the number of smoothing splines vs. SalePrice
      sliderInput(inputId = "splines",
                  label = "Smoothing splines:",
                  min = 1, max = 19, step = 2,
                  value = 5),

      # Select which neighbourhoods to exclude from the plot, as it can get cluttered quickly
      selectInput(inputId = "neighbourhoods",
                  label = "Exclude neighbourhoods:",
                  choices = all_neighbourhoods,
                  selected = exclude_neighbourhoods,
                  multiple = TRUE,
                  selectize = TRUE),
      # Place the boxplot on the lower left side
      plotOutput(outputId = "boxPlot")
    ),

    # Show scatter plot and table of selected data on the right side (main area)
    mainPanel(
      plotOutput(outputId = "scatterPlot", brush = "plot_brush"),
      htmlOutput(outputId = "instructions"),
      dataTableOutput(outputId = "houseTable"),
      br()
    )
  )
)

# Define server logic required to draw the plots
output$scatterPlot <- renderPlot({
  ggplot(data = house %>% filter(!(Neighborhood %in% input$neighbourhoods)),
         aes_string(x = input$x, y = "SalePrice")) +
    geom_point(aes_string(col = input$z)) +
    geom_smooth(method = "lm", formula = y ~ splines::bs(x, input$splines), se = F) +
    labs(
      y = "Sale Price ($)"
    )
})

output$boxPlot <- renderPlot({
  ggplot(data = house %>% filter(!(Neighborhood %in% input$neighbourhoods))) +
    geom_boxplot(aes_string(x = input$z, y = "SalePrice", fill = input$z)) +
    theme(legend.position="none",
          axis.title.y=element_blank(),
          axis.text.y=element_blank(),
          axis.ticks.y=element_blank()) +
    labs(
      x = ""
    )
})

output$instructions <- renderUI({
  HTML("Click and drag selection of observations in scatter plot to inspect closer.<br>")
})

# Create data table
output$houseTable <- DT::renderDataTable({
  brushedPoints(house, brush = input$plot_brush) %>%
    filter(!(Neighborhood %in% input$neighbourhoods)) %>%
    select(SalePrice, Neighborhood, TotalSF, HouseAge, SaleCondition, GarageCars, GarageAge)
})
```

3. Threshold analysis in a classification model

Interactive visualizations can be useful when working with machine learning classifications models. To illustrate this, we have used the "Bank Marketing" dataset from the UCI Machine Learning Repository. The data is related to a direct marketing campaign for a Portuguese bank. Our goal is to predict the outcome of a sales call when a sales representative is offering a new product.

A confusion matrix is used to evaluate the model. The matrix shows when the model gives true or false positives, and true or false negatives. Depending on the business case, different measures can be used to evaluate the model. The total accuracy, the share of correct predictions, might not be the adequate metric for a model. *Precision* and *recall* needs to be taken into account as well. Precision measures share of correct predictions among the predicted successes, while recall measures the correct predictions among the successful outcomes. Looking at the graph, we see that there is a trade-off between the two.

When the probability of belonging to a class reaches a set threshold, it will be classified to that class. Consequently, it is essential to adjust the threshold and see how the metrics changes. When the threshold slides is adjusted in the dashboard, the plot of the model metrics changes. The dashed line indicates the metrics associated with the set threshold. Moreover, we can explore metrics for different models. In our case, this is logistic regression (log), linear discriminant analysis (lda), and quadratic discriminant analysis (qda).

```
library(shiny)
library(ggplot2)
load(file = "logfit.Rdata")

fluidPage(

  # Application title
  titlePanel("Threshold Analysis"),

  # Sidebar with a slider input for number of bins
  sidebarLayout(
    sidebarPanel(
      sliderInput("threshold",
                  "Threshold:",
                  min = 0.00,
                  max = 0.50,
                  value = 0.25),
      selectInput("models",
                  "Model",
                  choices = c("log", "lda", "qda"))
    ),
    # Show a plot of the generated distribution
    mainPanel(
      plotOutput("logfit", width = "100%", height = "500px"),
      plotOutput("threshold", width = "100%", height = "500px")
      #, width = 12
    )
  )
)

output$logfit <- renderPlot({
  plot.list[[input$models]] + geom_vline(xintercept=input$threshold, linetype = "dashed", color = "blac
})

output$threshold <- renderPlot({
  confusion.matrix(table(ifelse(as.numeric(threshold.list[[input$models]] > input$threshold), 1, 0), te
                   tit = paste0(input$models, " classification probability threshold ", input$threshold
})
```

```r
load(file = "logfit.Rdata")

fluidPage(

  # Application title
  titlePanel("Threshold Analysis"),

  # Sidebar with a slider input for number of bins
  sidebarLayout(
    sidebarPanel(
      sliderInput("threshold",
                  "Threshold:",
                  min = 0.00,
                  max = 0.50,
                  value = 0.25),
      selectInput("models",
                  "Model",
                  choices = c("log", "lda", "qda"))
    ),
    # Show a plot of the generated distribution
    mainPanel(
      plotOutput("logfit", width = "100%", height = "500px"),
      plotOutput("threshold", width = "100%", height = "500px"),
      width = 12)
  )
)

output$logfit<- renderPlot({
  plot.list[[input$models]] + geom_vline(xintercept=input$threshold, linetype = "dashed", color = "blac
})

output$threshold <- renderPlot({
  confusion.matrix(table(ifelse(as.numeric(threshold.list[[input$models]] > input$threshold), 1, 0), te
                   tit = paste0(input$models, " classification probability threshold ", input$threshold

})
```