Project 1

Daniel Carpenter

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Introduction

Within the `Project1.Rmd` file and this `Project1.pdf` file, the user can create a linear regression between two variables; also, the user can use a bootstrapping function. Within the function `myslr`, the user estimates the relationship between two variables, as well show the confidence in those estimates.

Within the bootstrapping function `myboot`, the user can use a limited sample to infer information about a population's variance. The function will output a confidence interval, some summary statistics, and a histogram showing the possible outcomes of a given variable.

Data

Within the examples in this file, the `mtcars` data set provides meaningful information when estimating linear regressions and bootstrapping. This data set includes information from the 1974 *Motor Trends* US magazine, and "comprises fuel consumption," as well as "10 aspects" of each of the thirty-two cars in the data set. These "aspects" resemble the variables within the data, such as miles per gallon.

When considering the variables in the `mtcars` data set, it is useful to understand the types of data, which help best determine how to analyze the data. Please see the variables, their descriptions, and their data types below.

Variable Name	**Variable Description**	**Data Type**
mpg	Miles/(US) gallon	Ratio
cyl	Number of cylinders	Ratio
disp	Displacement (cu.in.)	Ratio
hp	Gross horsepower	Ratio
drat	Rear axle ratio	Ratio
wt	Weight (1000 lbs)	Ratio
qsec	1/4 mile time	Interval
vs	Engine (0 = V-shaped, 1 = straight)	Nominal
am	Transmission (0 = automatic, 1 = manual)	Nominal
gear	Number of forward gears	Ratio
carb	Number of carburetors	Ratio

Theory Used

$$Y = \beta_0 + \beta_i * X_i + \epsilon_i \tag{1}$$

`Y` Represents the dependent, or explained, variable.

$$\beta_0 \tag{2}$$

represents the estimated intercept.

$$\beta_i \tag{3}$$

represents the slope of the estimated vector.

$$X_i \tag{4}$$

represents the independent, or control, variable.

$$\epsilon_i \tag{5}$$

represents some error term.

Application of SLR to the mtcars data set

Making the SLR function: `myslr`

```
myslr <- function(data,
                    y, yName,
                    x, xName,
                    sizeVar, sizeVarName,
                    colVar, colVarName,
                    titleVar)
{
  # Open Window to View Plot
    windows(title = "Linear Estimation Graph for Y on X")

  # Create Plot
    plot <- ggplot(
                  # Data
                    data,

                  # Aesthetic Mapping
                    aes(x, y,
                       color  = colVar,
                       size   = sizeVar)) +

                  # Add Scatter Layer
                    geom_point(alpha = 2/5) +

                  # Add Linear Estimation
                    geom_smooth(method  = "lm",
                                formula = y ~ x,
                                color   = "grey35") +

                  # Titles
                    labs(title     = titleVar,
                         subtitle  = " ",
                         x         = xName,
                         y         = yName,
                         col       = colVarName,
                         size      = sizeVarName) +
```

```
                    # Theme
                      theme_get()

  # show Plot
    print(plot)

  # Save plot
    ggsave(filename  = paste0(titleVar, ".png"),
           plot      = plot,
           height    = 6,
           width     = 8)


  # Linear Estimation and Summary Output

    ## Linear Regression (returned)
      y.lm <- lm(y ~ x)

    ## Linear Regression Output (void)
      print(summary(y.lm))

    ## Confidence Interval at 95% (void)
      CI <- ciReg(y.lm)
      CI
      write.csv(CI, file = "Confidence Intervals.csv")

    ## Check assumptions and save .png
      png("Normal Interval Check.png", height = 150, width = 500)
      normcheck(y.lm)
      dev.off()

    ## Check residuals and save .png
      png("Fitted vs. residuals Plot.png", height = 250, width = 500)
      plot(y.lm, which = 1)
      dev.off()

    ## Linear Estimation
      return(y.lm)
}
```

Invoke `myslr` function using the `mtcars` data set

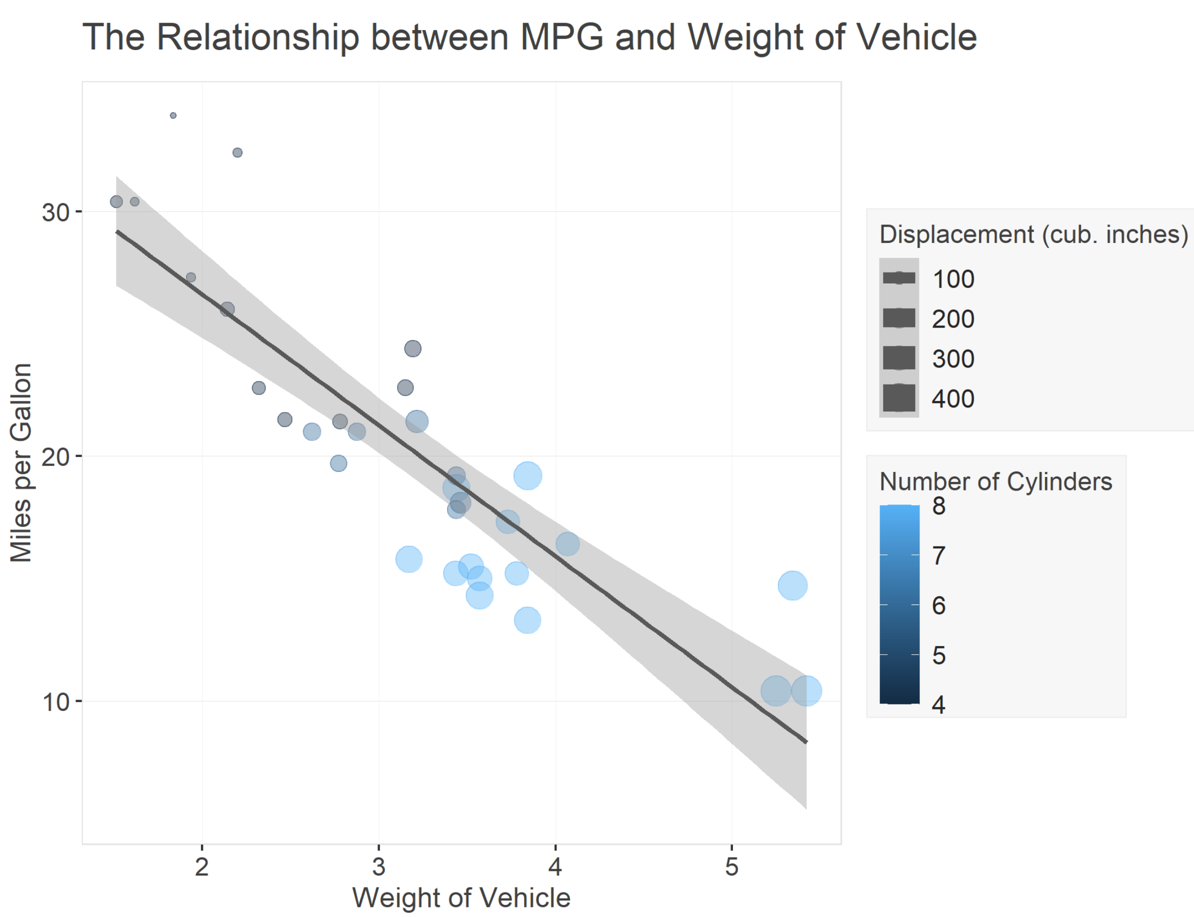
```
# Call Get Linear Estimation for y on x
  y.lm <- myslr(data = mtcars,
                mtcars$mpg,   "Miles per Gallon",
                mtcars$wt,    "Weight of Vehicle",
                mtcars$disp,  "Displacement (cub. inches)",
                mtcars$cyl,   "Number of Cylinders",
                "The Relationship between MPG and Weight of Vehicle")
```

```
##
## Call:
## lm(formula = y ~ x)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

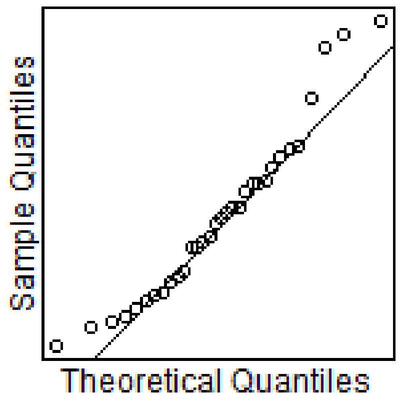
```
## -4.5432 -2.3647 -0.1252  1.4096  6.8727
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  37.2851     1.8776  19.858  < 2e-16 ***
## x            -5.3445     0.5591  -9.559 1.29e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.046 on 30 degrees of freedom
## Multiple R-squared:  0.7528, Adjusted R-squared:  0.7446
## F-statistic: 91.38 on 1 and 30 DF,  p-value: 1.294e-10
##
##             95 % C.I.lower    95 % C.I.upper
## (Intercept)       33.45050          41.11975
## x                 -6.48631          -4.20263
```

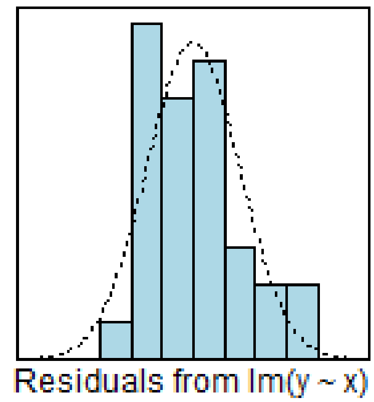
```
  # Coefficient list
    coefsList <- y.lm$coefficients
```

Plot Output

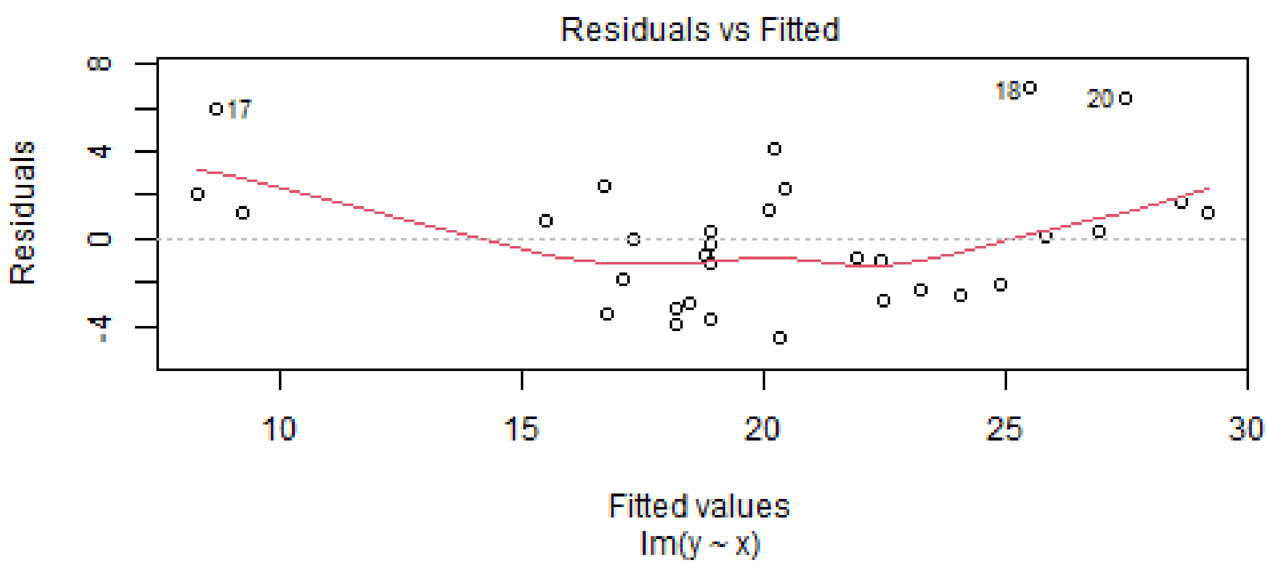


Normal Interval Check





Fitted vs. Residuals



Interpretation of Model

Within the model, it estimates that an increase of 1,000 pounds in weight of a given car decreases the miles per gallon of the vehicle by 5.34. Additionally, the model estimates that changes in weight account for 75.28% of the variation in the car's miles per gallon.

At a 95% level of confidence, the model estimates the lower bound to be a 6.49 decrease in miles per gallon when increasing the weight of a car by 1,000 pounds. Alternatively, the model estimates the upper bound to be a 4.20 decrease in miles per gallon when increasing the weight of a car by 1,000 pounds.

Validity of the Model

Although the model estimates a narrow confidence interval with a relatively high R-squared value, we may not assume that solely weight accounts for the full 76.28% variation in miles per gallon. This variable could easily be correlated with another relevant variable, thus confounding the simple linear regression.

Bootstrap

Make Bootstrap Function

```r
myboot <- function(iter   = 10000, # num iterations
                   x,              # dataset
                   fun    = "var", #
                   alpha  = 0.05,  # 95% confidence
                   cx     = 1.5,
                   ...
                   )
{
  # Get Sample size
    n = length(x)

  # Create Sample
    y = sample(x,
               n * iter,
               replace = TRUE)

  # Form Matrix from sample
    rs.mat = matrix(y, # data from sampling
                    nrow  = n,
                    ncol  = iter,
                    byrow = TRUE) # sort by row

  # Variance
    xstat = apply(rs.mat, 2, fun) # vector containing iter vals

  # Form confidence interval
    ci = quantile(xstat,
                  c(alpha / 2,
                    1 - alpha / 2)
                    )

  # Send summary Statistics to the console

    ## Confidence Interval Out
      print("____________________________________________")
      print(paste0("Confidence Interval at Alpha = ", alpha))
      print("--------------------------------------------")
      print(ci)


    ## Form matrix of sample stats
    statNames <- c("Mean:", "Median:", "Standard Deviation:")
    statVals  <- c(comma(mean  (xstat), digits = 2),
                   comma(median(xstat), digits = 2),
                   comma(sd    (xstat), digits = 2)
                   )
    summaryStats <- matrix(data = c(statNames,
                                    statVals),
                           nrow = 3,
                           ncol = 2)

    ##  Sample Stats Out
```

```
    print("____________________________________________")
    print("Summary Statistics from Bootstrap Sampling:")
    print("--------------------------------------------")
    print(summaryStats)

  # Create a histogram from Bootstrap sampling
    para <-  hist(
                  xstat,
                  freq = FALSE, # along numberline, not freq
                  las  = 1,
                  main = paste0("Histogram of Bootstrap Sample Statistics",
                                "\n",
                                "Alpha = ", alpha, "; ",
                                "Iters = ", comma(iter, digits = 0)),
                  col  = alpha("skyblue3", 2/5),
                  ...)

    # Save Bootstrap plot
      png("Bootstrap Estimate Plot.png", height = 150, width = 500)
      para
      dev.off()

    # write a file to current directory with sample data
      write.csv(xstat, "Bootstrap Estimations.csv")

    return(xstat)
}
```

Invoke `myboot` Function

Get data from `mtcars`, while only containing 4 cylinder cars

```
  # Get dataset from mtcars
  df <- mtcars %>%

    ## filter to only 4-cylinder cars
      filter(cyl == 4) %>%

    ## Only show vars of interest
      select(mpg)

    ## Store as vector
      df.vector <- df$mpg
```

Call `myboot` Function and Store Estimations in List

```r
varianceData <- myboot(iter  = 10000,
                       x     = df.vector,
                       alpha = 0.05,
                       cx    = 1.5,
                       xlab  = "Variance of MPG")
```

```
## [1] "____________________________________________"
## [1] "Confidence Interval at Alpha = 0.05"
## [1] "--------------------------------------------"
##      2.5%     97.5%
##  8.506909 28.430909
## [1] "____________________________________________"
## [1] "Summary Statistics from Bootstrap Sampling:"
## [1] "--------------------------------------------"
##      [,1]                   [,2]
## [1,] "Mean:"                "18.4292932363636"
## [2,] "Median:"              "18.3828181818182"
## [3,] "Standard Deviation:"  "5.08501472032832"
```