Data Analysis Practice

Michael V Cumbo

January 30, 2024

Objective

Explore the relationship between miles per gallon (*mpg*) and other variables in the `mtcars` dataset.

Tasks

1. Load the `mtcars` Dataset

- Start by loading the `mtcars` dataset into R. This dataset comes pre-loaded in R, so you don't need to download it from anywhere. Just use `data(mtcars)` to load it.

2. Basic Exploration

- Display the first few rows of the dataset using the `head()` function.
- Use the `summary()` function to get a summary of the dataset.

```r
library(tidyverse)
library(dplyr)

mtcars <- mtcars

head(mtcars)
```

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
##                   mpg_category
## Mazda RX4             High MPG
## Mazda RX4 Wag         High MPG
## Datsun 710            High MPG
## Hornet 4 Drive        High MPG
## Hornet Sportabout      Low MPG
## Valiant                Low MPG
```

```r
mtcars %>%
  summary()
```

```
##       mpg             cyl             disp             hp       
##  Min.   :10.40   Min.   :4.000   Min.   : 71.1   Min.   : 52.0  
##  1st Qu.:15.43   1st Qu.:4.000   1st Qu.:120.8   1st Qu.: 96.5  
##  Median :19.20   Median :6.000   Median :196.3   Median :123.0  
##  Mean   :20.09   Mean   :6.188   Mean   :230.7   Mean   :146.7  
##  3rd Qu.:22.80   3rd Qu.:8.000   3rd Qu.:326.0   3rd Qu.:180.0  
##  Max.   :33.90   Max.   :8.000   Max.   :472.0   Max.   :335.0  
##       drat             wt             qsec             vs        
##  Min.   :2.760   Min.   :1.513   Min.   :14.50   Min.   :0.0000  
##  1st Qu.:3.080   1st Qu.:2.581   1st Qu.:16.89   1st Qu.:0.0000  
##  Median :3.695   Median :3.325   Median :17.71   Median :0.0000  
##  Mean   :3.597   Mean   :3.217   Mean   :17.85   Mean   :0.4375  
##  3rd Qu.:3.920   3rd Qu.:3.610   3rd Qu.:18.90   3rd Qu.:1.0000  
##  Max.   :4.930   Max.   :5.424   Max.   :22.90   Max.   :1.0000  
##        am              gear            carb       mpg_category      
##  Min.   :0.0000   Min.   :3.000   Min.   :1.000   Length:32         
##  1st Qu.:0.0000   1st Qu.:3.000   1st Qu.:2.000   Class :character  
##  Median :0.0000   Median :4.000   Median :2.000   Mode  :character  
##  Mean   :0.4062   Mean   :3.688   Mean   :2.812                     
##  3rd Qu.:1.0000   3rd Qu.:4.000   3rd Qu.:4.000                     
##  Max.   :1.0000   Max.   :5.000   Max.   :8.000                     
```

3. Data Analysis

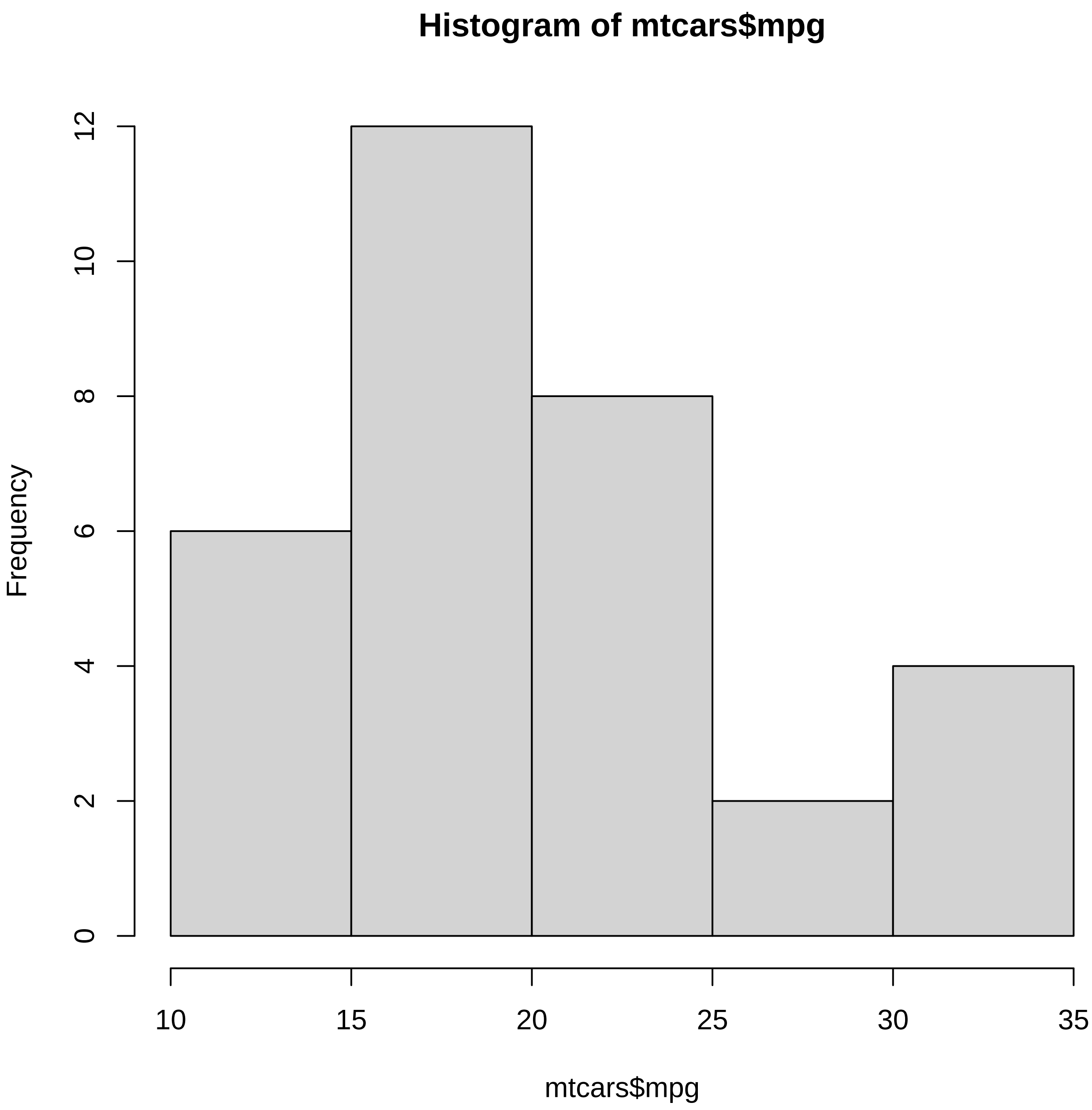
- Create a new column in the dataset that categorizes cars into "High MPG" and "Low MPG" based on whether their *mpg* is above or below the median *mpg* of all cars in the dataset. You can use the `ifelse()` function for this.

```r
mtcars <- mtcars %>%
  mutate(mpg_category = ifelse(mpg > 20.09, "High MPG", "Low MPG"))
```

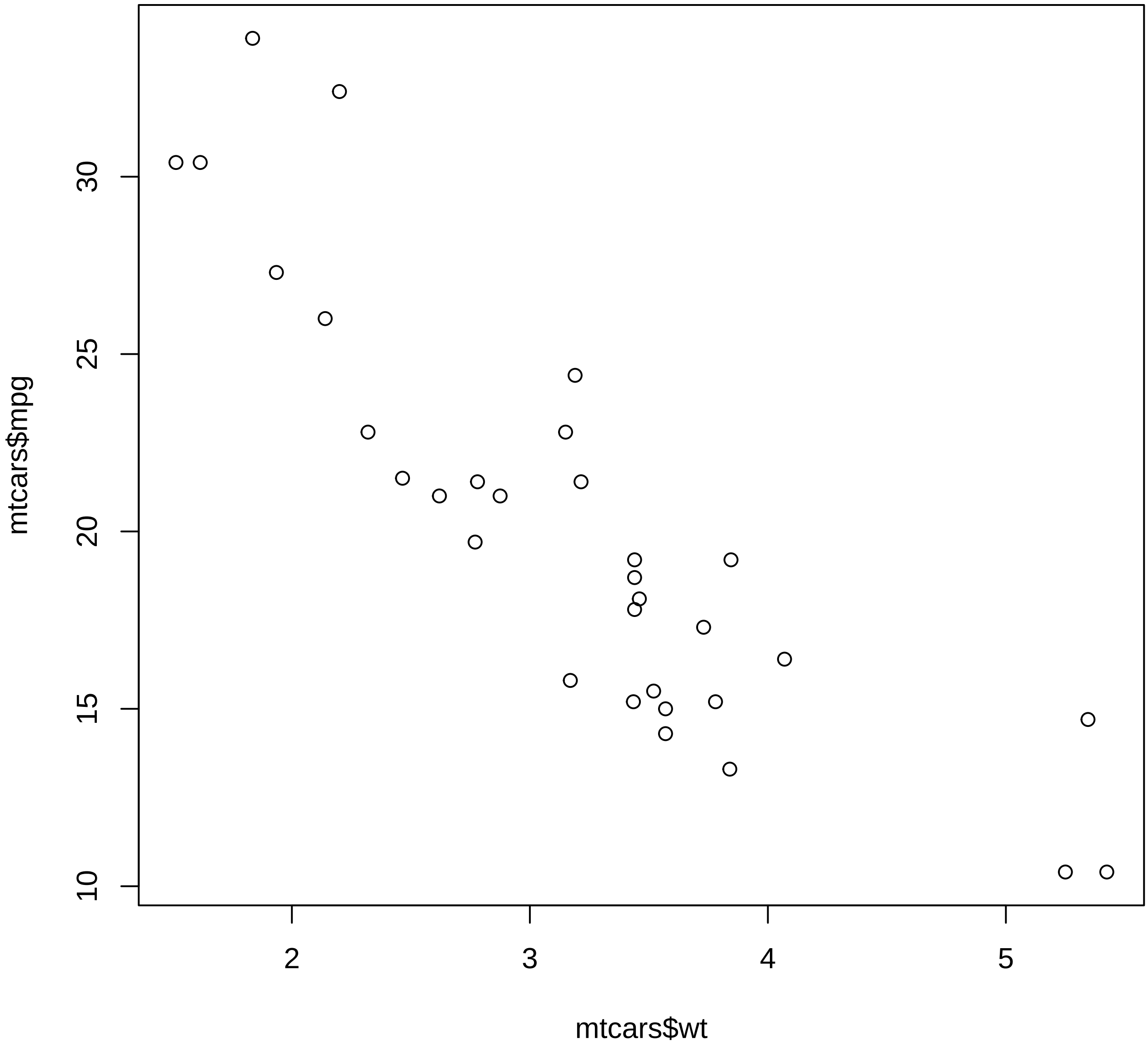
4. Visualization

- Plot a histogram of *mpg* to see its distribution.
- Create a scatter plot to examine the relationship between *mpg* and weight (`wt`).
- Bonus: Color the points in your scatter plot based on the "High MPG" and "Low MPG" categorization.

```r
hist(mtcars$mpg)
```




```r
plot(mtcars$wt, mtcars$mpg)
```



mtcars$mpg
10
15
20
25
30
2
3
4
5
mtcars$wt

5. Advanced Analysis (Optional)

- Perform a linear regression analysis to study the relationship between *mpg* (as the dependent variable) and other variables like weight (`wt`), horsepower (`hp`), and number of cylinders (`cyl`). Use the `lm()` function for this.
- Summarize your linear regression model using the `summary()` function and interpret the results.

```
library(tidyverse)
# Define the independent variables
independent_vars <- c("hp", "cyl", "drat", "qsec", "vs", "carb")
# Create a list of formulas
formulas <- lapply(
  independent_vars,
  function(var) as.formula(paste("mpg ~", var))
)
# Use map() to apply lm() to each formula
models <- map(formulas, ~ lm(data = mtcars, formula = .))
# Create a tibble with model summaries
model_summaries <- tibble(variable = independent_vars, model = models) %>%
  mutate(summary = map(model, summary))
# View the tibble
print(model_summaries)
```

```
## # A tibble: 6 x 3
##   variable model  summary
##   <chr>    <list> <list>
## 1 hp       <lm>   <smmry.lm>
## 2 cyl      <lm>   <smmry.lm>
## 3 drat     <lm>   <smmry.lm>
## 4 qsec     <lm>   <smmry.lm>
## 5 vs       <lm>   <smmry.lm>
## 6 carb     <lm>   <smmry.lm>
```

```
# Extract and print the summary
# for the model with 'hp' as the independent variable
hp_model_summary <- model_summaries %>%
  filter(variable == "hp") %>%
  pull(summary)
# Display the summary
print(hp_model_summary)
```

```
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q
## -5.7121 -2.1122 -0.8854  1.5819
##     Max
##  8.2360
##
## Coefficients:
##             Estimate Std. Error
## (Intercept) 30.09886    1.63392
```

```
## hp          -0.06823    0.01012
##             t value Pr(>|t|)
## (Intercept)  18.421  < 2e-16 ***
## hp           -6.742 1.79e-07 ***
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.863 on 30 degrees of freedom
## Multiple R-squared:  0.6024,Adjusted R-squared:  0.5892
## F-statistic: 45.46 on 1 and 30 DF,  p-value: 1.788e-07
##
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q
## -4.9814 -2.1185  0.2217  1.0717
##     Max
##  7.5186
##
## Coefficients:
##             Estimate Std. Error
## (Intercept)  37.8846     2.0738
## cyl          -2.8758     0.3224
##             t value Pr(>|t|)
## (Intercept)   18.27  < 2e-16 ***
## cyl           -8.92 6.11e-10 ***
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.206 on 30 degrees of freedom
## Multiple R-squared:  0.7262,Adjusted R-squared:  0.7171
## F-statistic: 79.56 on 1 and 30 DF,  p-value: 6.113e-10
##
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q
## -9.0775 -2.6803 -0.2095  2.2976
##     Max
##  9.0225
##
## Coefficients:
##             Estimate Std. Error
## (Intercept)   -7.525      5.477
## drat           7.678      1.507
##             t value Pr(>|t|)
## (Intercept)  -1.374     0.18
## drat          5.096 1.78e-05 ***
```

```
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.485 on 30 degrees of freedom
## Multiple R-squared:  0.464,Adjusted R-squared:  0.4461
## F-statistic: 25.97 on 1 and 30 DF,  p-value: 1.776e-05
##
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q
## -9.8760 -3.4539 -0.7203  2.2774
##     Max
## 11.6491
##
## Coefficients:
##             Estimate Std. Error
## (Intercept)  -5.1140    10.0295
## qsec          1.4121     0.5592
##             t value Pr(>|t|)
## (Intercept)  -0.510   0.6139
## qsec          2.525   0.0171 *
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.564 on 30 degrees of freedom
## Multiple R-squared:  0.1753,Adjusted R-squared:  0.1478
## F-statistic: 6.377 on 1 and 30 DF,  p-value: 0.01708
##
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -6.757 -3.082 -1.267  2.828  9.383
##
## Coefficients:
##             Estimate Std. Error
## (Intercept)   16.617      1.080
## vs             7.940      1.632
##             t value Pr(>|t|)
## (Intercept)  15.390 8.85e-16 ***
## vs            4.864 3.42e-05 ***
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.581 on 30 degrees of freedom
```

```
## Multiple R-squared:  0.4409,Adjusted R-squared:  0.4223
## F-statistic: 23.66 on 1 and 30 DF,  p-value: 3.416e-05
##
##
## Call:
## lm(formula = ., data = mtcars)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -7.250 -3.316 -1.433  3.384 10.083
##
## Coefficients:
##             Estimate Std. Error
## (Intercept)  25.8723     1.8368
## carb         -2.0557     0.5685
##             t value Pr(>|t|)
## (Intercept)  14.085 9.22e-15 ***
## carb         -3.616  0.00108 **
## ---
## Signif. codes:
##   0 '***' 0.001 '**' 0.01 '*'
##   0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.113 on 30 degrees of freedom
## Multiple R-squared:  0.3035,Adjusted R-squared:  0.2803
## F-statistic: 13.07 on 1 and 30 DF,  p-value: 0.001084
```

6. Reflection

- Write a brief summary of your findings. Which variables seem to affect *mpg* the most? Were there any surprises in your analysis?

Deliverables

- R script with your code and comments explaining each step.
- A brief report summarizing your findings.

1. **Horsepower (hp):**
   - Coefficient: -0.06823. This indicates that for every unit increase in horsepower, mpg decreases by approximately 0.06823 units.
   - P-value: 1.79×10^{-7}, showing a strong negative relationship between horsepower and mpg.
2. **Number of Cylinders (cyl):**
   - Coefficient: -2.8758, suggesting a substantial decrease in mpg with each additional cylinder.
   - P-value: 6.11×10^{-10}, indicating a strong inverse relationship between the number of cylinders and mpg.
3. **Rear Axle Ratio (drat):**
   - Coefficient: 7.678, showing a positive relationship with mpg.
   - P-value: 1.78×10^{-5}, suggesting that cars with higher rear axle ratios tend to have better fuel efficiency.
4. **1/4 Mile Time (qsec):**
   - Coefficient: 1.4121, indicating that cars with faster quarter-mile times tend to have slightly higher mpg.
   - P-value: 0.0171, though with a lower R-squared value, suggesting a weaker overall model fit.
5. **Engine Configuration (vs):**
   - Coefficient: 7.940, showing a strong positive effect on mpg.
   - P-value: 3.42×10^{-5}, indicating that engine configuration has a notable impact on fuel efficiency.
6. **Number of Carburetors (carb):**
   - Coefficient: -2.0557, suggesting that more carburetors are associated with lower mpg.
   - P-value: 0.00108.

In conclusion, the number of cylinders (`cyl`) and horsepower (`hp`) show the strongest negative relationships with mpg, indicating that cars with more cylinders and higher horsepower tend to have lower fuel efficiency. Conversely, the rear axle ratio (`drat`) and engine configuration (`vs`) positively impact mpg. Notably, the significant effect of the rear axle ratio highlights the importance of transmission and powertrain characteristics in determining fuel efficiency.