Regression Models Course Project

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Executive Summary

You work for Motor Trend, a magazine about the automobile industry. Looking at a data set of a collection of cars, they are interested in exploring the relationship between a set of variables and miles per gallon (MPG) (outcome). They are particularly interested in the following two questions:

- Is an automatic or manual transmission better for MPG
- Quantify the MPG difference between automatic and manual transmissions

Exploring the dataset

```
echo = TRUE
options(width=80)
knitr::opts_chunk$set(out.width="400px", dpi=120)
library(ggplot2) #for plots
```

```
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
```

```
data(mtcars)
summary(mtcars)
```

```
##       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
##  Min.   :0.0000   Min.   :3.000   Min.   :1.000
##  1st Qu.:0.0000   1st Qu.:3.000   1st Qu.:2.000
##  Median :0.0000   Median :4.000   Median :2.000
##  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
```

```
# Transform certain variables into factors
mtcars$cyl  <- factor(mtcars$cyl)
mtcars$vs   <- factor(mtcars$vs)
mtcars$gear <- factor(mtcars$gear)
mtcars$carb <- factor(mtcars$carb)
mtcars$am   <- factor(mtcars$am,labels=c("Automatic","Manual"))
### view From appendix fig. 1  MPG Distribution
```

Regression Analysis

```
aggregate(mpg~am, data = mtcars, mean)
```

We've visually seen that automatic is better for MPG, but we will now quantify his difference. From appendix fig. 2

```
##          am      mpg
## 1 Automatic 17.14737
## 2    Manual 24.39231
```

```
fit_simple <- lm(mpg ~ factor(am), data=mtcars)
summary(fit_simple)
```

We will use mpg as the dependent variable and am as the independent variable to fit a linear regression, where Beta1 is the group mean for automatic and Beta0 is the intercept.

```
##
## Call:
## lm(formula = mpg ~ factor(am), data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.3923 -3.0923 -0.2974  3.2439  9.5077
##
```

```
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)         17.147      1.125  15.247 1.13e-15 ***
## factor(am)Manual     7.245      1.764   4.106 0.000285 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.902 on 30 degrees of freedom
## Multiple R-squared:  0.3598, Adjusted R-squared:  0.3385
## F-statistic: 16.86 on 1 and 30 DF,  p-value: 0.000285
```

It shows that on average, a car has 17.147 mpg with automatic transmission, and if it is manual transmission, 7.245 mpg is increased. This model has the Residual standard error as 4.902 on 30 degrees of freedom. And the Adjusted R-squared value is 0.3385, which means that the model can explain about 34% of the variance of the MPG variable. The low Adjusted R-squared value also indicates that other variables should be added to the model.

Anova test and Residuals

```
init <- lm(mpg ~ am, data = mtcars)
###summary(init)
betterFit <- lm(mpg~am + cyl + disp + hp + wt, data = mtcars)
####betterFit <-  lm(mpg ~ am + wt + qsec, data = mtcars)
anova(init, betterFit)
```

Finally, the final model is selected.

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + cyl + disp + hp + wt
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1     30 720.90
## 2     25 150.41  5    570.49 18.965 8.637e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This results in a p-value of 8.637e-08, and we can claim the betterFit model is significantly better than our init simple model. We double-check the residuals for non-normality and can see they are all normally distributed and homoskedastic.

Residual Analysis and Diagnostics

According to the residual plots, the following underlying assumptions can be varified: From appendix fig. 3

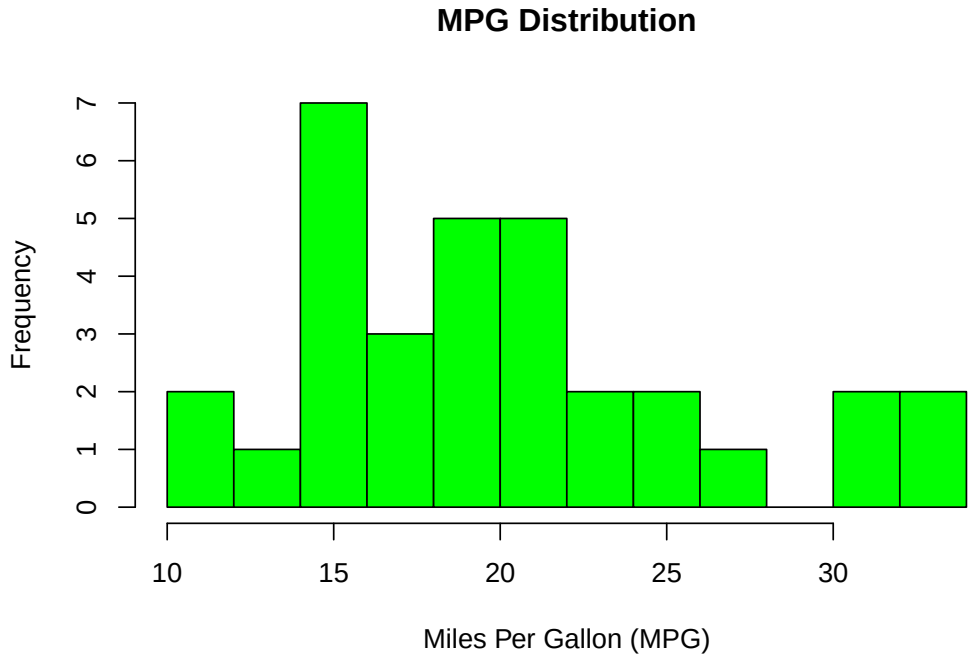
1. The Residuals vs. Fitted plot shows no consistent pattern, supporting the accuracy of the independence assumption.

2. The Normal Q-Q plot indicates that the residuals are normally distributed
   because the points lie closely to the line.
3. The Scale-Location plot confirms the constant variance assumption,
   as the points are randomly distributed.
4. The Residuals vs. Leverage argues that no outliers are present,
   as all values fall well within the 0.5 bands.

Appendix: Figures

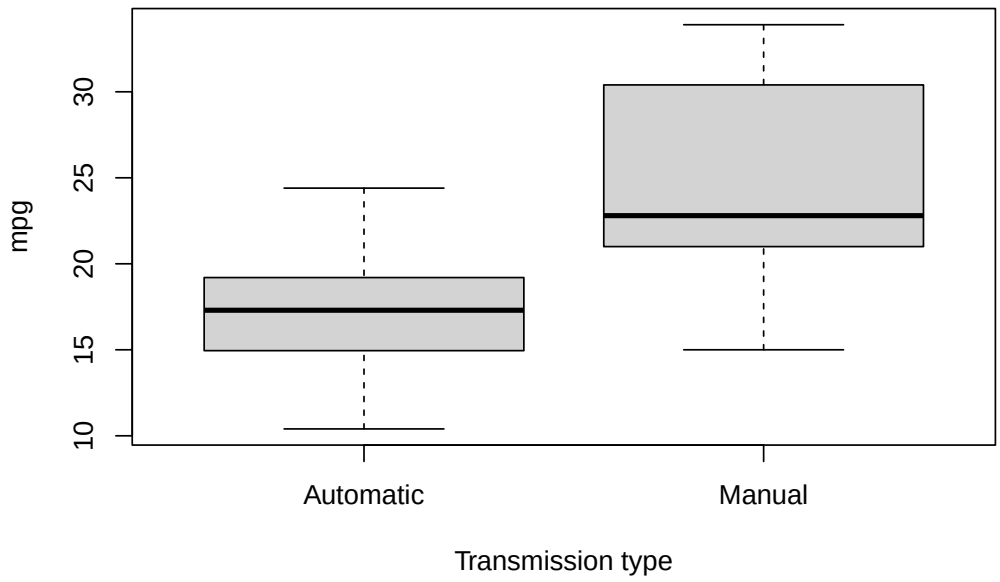
MPG Distribution fig. 1

```
## Histgram of MPG
hist(mtcars$mpg, breaks=12, xlab="Miles Per Gallon (MPG)", main="MPG Distribution",
     col="green")
```



Transmission type fig. 2

```
boxplot(mpg ~ am, data = mtcars, xlab = "Transmission type")
```



Residual plots fig. 3

```
par(mfrow = c(2,2))
plot(betterFit)
```