Regression models Course Assignment

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Introduction and Summary

This document answers two main questions:

1. Is an automatic or manual transmission better for MPG?
2. What is the MPG difference between automatic and manual transmissions?

The data are described in the Data section. Analytical methodology is discussed in Methods and Results. Findings relevent to the questions are provided in the Discussion section. Further information and graphs are available in the Appendix.

Data

The *mtcars* dataset is used as the basis for analysis. More information on this dataset can be obtained with ?*mtcars*.

Methods and Results

Using a scatterplot matrix (see Appendix), one observes that most of the predictors seem to have some impact on MPG. At this point, no obvious outliers are identified.

We next build a linear model with all variables.

```
fit <- lm(mpg ~ ., data=df)
summary(fit)
```

None of the variables exhibit a P-value smaller than 0.05. By selecting a subset of these variables using AIC stepwise selection and the regsubsets function from the *leaps* package, we see:

```
# AIC stepwise selection (both direction)
library(MASS)
stepB <- stepAIC(fit, direction="both")
# confirming our variable selection with a second method
library(leaps)
leaps <- regsubsets(mpg ~ ., data = df, nbest = 10)
```

Both methods recommend *wt, am, hp and cyl* as predictors in the model, and we identify our variable of interest *am* (see Appendix for the results of the regsubsets function).

```
fitR <- lm(mpg ~ wt + am + hp + cyl, data=df)
summary(fitR)
```

The intercept and the variables *wt*, *hp* and *cyl6* show p-values smaller than 0.05.

Based on consideration of the residuals plots, it seems that the model has some difficulty to fit the data with low or high MPG values. An examination of the scatterplot matrix may identify possible corrections (see Appendix).

There seems to be a nonlinear relationship between *mpg* and *wt*. Using log(wt) instead of wt may improve the model, and yields the following residual plots:

```
fitR2 <- lm(mpg ~ log(wt) +  hp + cyl + am, data=df)
anova(fitR2)
```

The curvature of the residuals vs fitted values has been reduced. Similarly, the squared of the standardized residuals plot no longer displayes an increasing slope. The normal Q-Q plots display less deviation from the normal for the error term. Based on the plot "standardized residuals vs leverage", none of the points is above a Cook's distance threshold of 0.5, which indicates that none of the points distort the outcome and accuracy of our regression model. See Appendix for more details.

The hat values obtained with the influence function describe the influence each observed value has on each fitted value. One point in particular, "Maserati Bora", seems to have more influence on the fitted values; however this, point is not dramatically high (see Appendix). The final selected model is *mpg ~ log(wt) + hp + cyl + am*.

Discussion

In this section both questions mentioned in the Introduction are answered based the model built in Section Methods and results. Summary of the model is given the Appendix.

A brief explanation of the coefficients of the model:

- Numerical variables
  - for every 1% increase in *log(wt)* we expect a decrease of 10.133 in *mpg*
  - for every 1% increase in *hp* we expect a decrease of 0.027 in *mpg*
- Factor variables
  - if we have 6 cylinders (*cyl6*), *mpg* changes by -2.205 compared to having 4 cylinders
  - if we have 8 cylinders (*cyl8*), *mpg* changes by -1.789 compared to having 4 cylinders
  - if we have a manual transmission (*am1*), *mpg* changes by 0.867 compared to having an automatic transmission

```
(ci <- confint(fitR2))
```

```
##                    2.5 %       97.5 %
## (Intercept)  30.52014642 42.2557456987
## log(wt)     -16.07153044 -4.1945572966
## hp           -0.05441425 -0.0003648742
## cyl6         -5.04344839  0.6333139289
## cyl8         -6.22770611  2.6496674261
## am1          -2.03562296  3.7688902021
```

Looking at the 95%-confidence interval of the estimates, one observes that the AM variable shows the interval [-2.04,3.77], so it is not possible to tell whether an automatic transmission is better for MPG than a manual one. With the likelihood ratio test, we can say at least that adding the AM term in our model is not significantly better for estimating MPG as shown in the Appendix.

Appendix

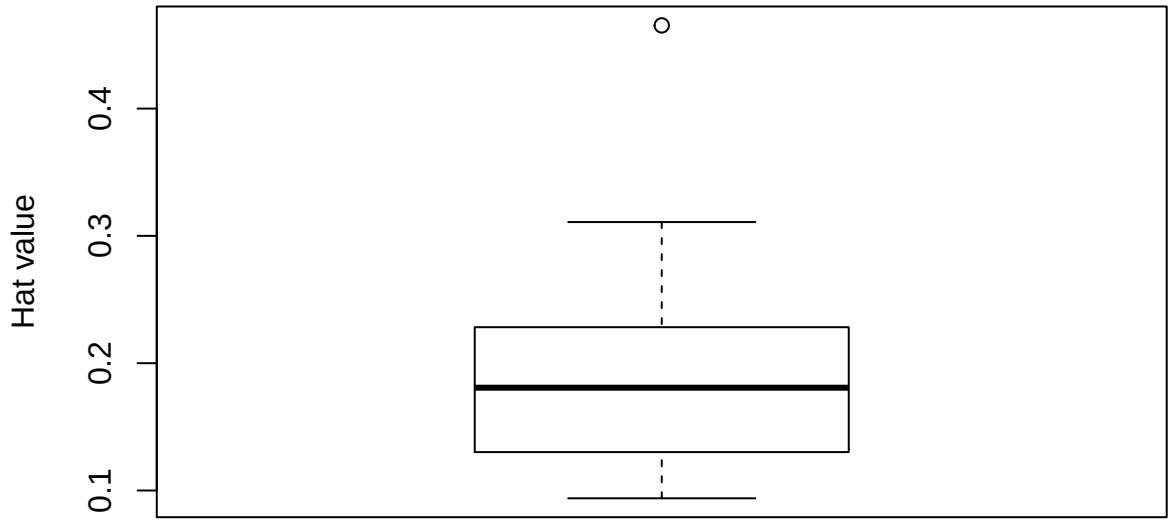
Fit using all variables.

```
summary(fit)
```

```
##
## Call:
## lm(formula = mpg ~ ., data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.5087 -1.3584 -0.0948  0.7745  4.6251
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 23.87913   20.06582   1.190   0.2525
## cyl6        -2.64870    3.04089  -0.871   0.3975
## cyl8        -0.33616    7.15954  -0.047   0.9632
## disp         0.03555    0.03190   1.114   0.2827
## hp          -0.07051    0.03943  -1.788   0.0939 .
## drat         1.18283    2.48348   0.476   0.6407
## wt          -4.52978    2.53875  -1.784   0.0946 .
## qsec         0.36784    0.93540   0.393   0.6997
## vs1          1.93085    2.87126   0.672   0.5115
## am1          1.21212    3.21355   0.377   0.7113
## gear4        1.11435    3.79952   0.293   0.7733
## gear5        2.52840    3.73636   0.677   0.5089
## carb2       -0.97935    2.31797  -0.423   0.6787
## carb3        2.99964    4.29355   0.699   0.4955
## carb4        1.09142    4.44962   0.245   0.8096
## carb6        4.47757    6.38406   0.701   0.4938
## carb8        7.25041    8.36057   0.867   0.3995
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.833 on 15 degrees of freedom
## Multiple R-squared:  0.8931, Adjusted R-squared:  0.779
## F-statistic:  7.83 on 16 and 15 DF,  p-value: 0.000124
```

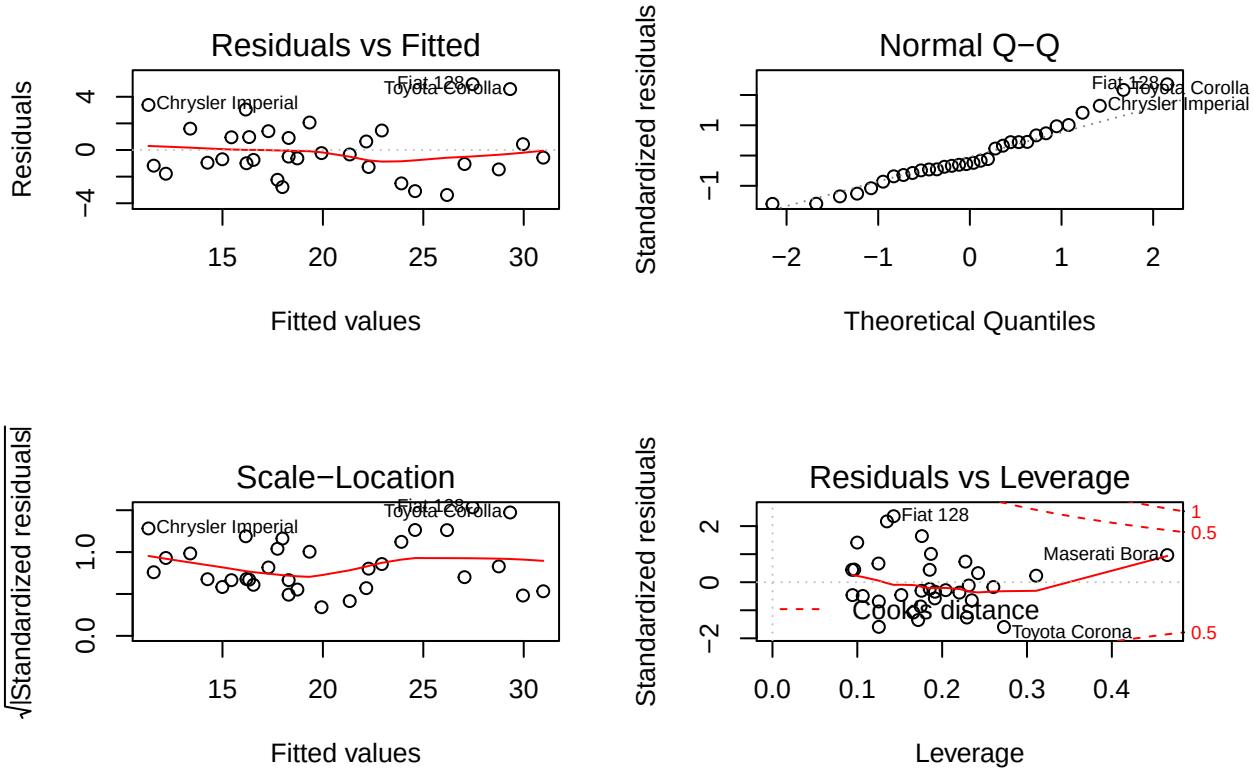
Boxplot of the hat values for the model *mpg ~ log(wt) + am + hp + cyl*

```
boxplot(hat,ylab="Hat value")
```



Residuals for the model $mpg \sim log(wt) + am + hp + cyl$

```
par(mfrow=c(2,2))
plot(fitR2)
```



Fit summary for the model *mpg ~ log(wt) + am + hp + cyl*

```
summary(fitR2)
```

```
##
## Call:
## lm(formula = mpg ~ log(wt) + hp + cyl + am, data = df)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -3.380 -1.202 -0.534  1.081  4.943
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  36.38795    2.85464  12.747 1.09e-12 ***
## log(wt)     -10.13304    2.88903  -3.507  0.00166 **
## hp           -0.02739    0.01315  -2.083  0.04720 *
## cyl6         -2.20507    1.38085  -1.597  0.12237
## cyl8         -1.78902    2.15939  -0.828  0.41494
## am1           0.86663    1.41193   0.614  0.54468
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.269 on 26 degrees of freedom
## Multiple R-squared:  0.8811, Adjusted R-squared:  0.8583
## F-statistic: 38.54 on 5 and 26 DF,  p-value: 3.214e-11
```

Comparing the models with and without *am* (*mpg ~ log(wt) + am + hp + cyl* VS *mpg ~ log(wt) + hp + cyl*)

```
## Likelihood ratio test
##
## Model 1: mpg ~ log(wt) + hp + cyl + am
## Model 2: mpg ~ log(wt) + hp + cyl
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1   7 -68.303
## 2   6 -68.533 -1 0.4604     0.4975
```