Motor Trend Car Road Tests

Regression Models Course Project

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Contents

Abstract

In this study we make an attempt to evaluate whether transmission type of an automobile is a significant predictor for a vehicle efficiency expressed in miles per gallon. Moreover it is important to check whether other parameters appear to be significant predictors.

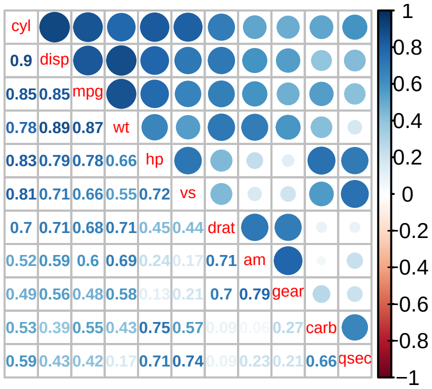
Exploratory analysis

We will perform the study on a standard mtcars dataset included in R:

> The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973–74 models).
> R help

```
##                 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
```

For the sake of visual simplicity we will rearrange each variable according with total amount of correlation with other variables. In this way a more visually clear correlation plot can be built:

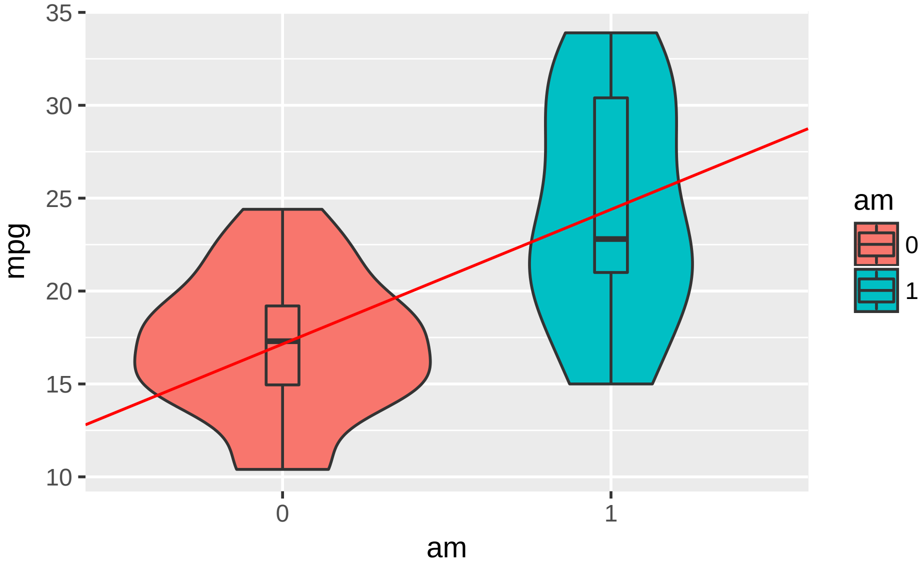


From this plot one can obtain a general understanding of which variables correlate with the most other variables.

Simple linear modeling

Since the outcome, mpg, is an interval variable, it is reasonable to use simple linear model for the whole study. The first obvious step is to create a simple model with one predictor, am

```
##
## Call:
## lm(formula = mpg ~ 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 ***
## am1            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
```



The line seems to be fitting the trend for the two groups and the p-values are highly significant. However, Adjusted R-squared points out that this model accounts for only 34% of variance in the data. Hence, we should expand the model to include more variables. Not all the available variables are necessary in the model, and we know that excess variables cause variance inflation and overfiting.

Multivariate regression

Below is a full model containing all the variables as predictors. As can be seen from the output, even though the Adjusted R-squared is rather high, none of the coefficents are even remotely significant.

```
##
## Call:
```

```
## lm(formula = mpg ~ ., data = mtcars)
##
## 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
```

We will use stepwise model selection procedure to sort out variables which do not contribute to the interpretability.

```
##
## Call:
## lm(formula = mpg ~ cyl + hp + wt + am, data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.9387 -1.2560 -0.4013  1.1253  5.0513
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 33.70832    2.60489  12.940 7.73e-13 ***
## cyl6        -3.03134    1.40728  -2.154  0.04068 *
## cyl8        -2.16368    2.28425  -0.947  0.35225
## hp          -0.03211    0.01369  -2.345  0.02693 *
## wt          -2.49683    0.88559  -2.819  0.00908 **
## am1          1.80921    1.39630   1.296  0.20646
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.41 on 26 degrees of freedom
## Multiple R-squared:  0.8659, Adjusted R-squared:  0.8401
## F-statistic: 33.57 on 5 and 26 DF,  p-value: 1.506e-10
```

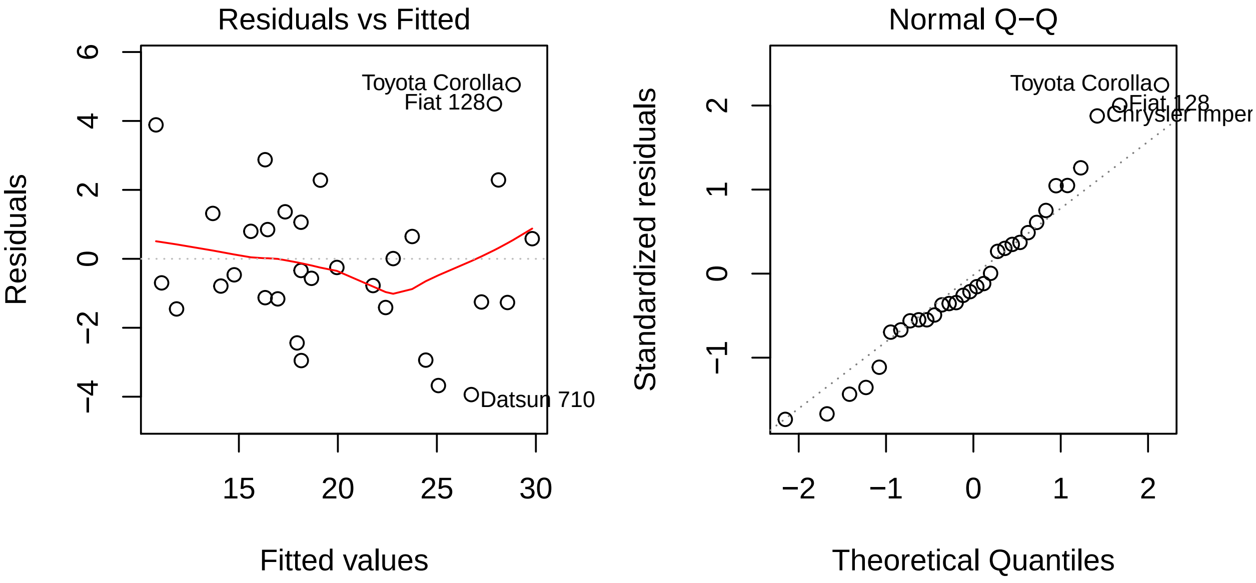
```
##         GVIF Df GVIF^(1/(2*Df))
## cyl 5.824545  2        1.553515
## hp  4.703625  1        2.168784
## wt  4.007113  1        2.001778
## am  2.590777  1        1.609589
```

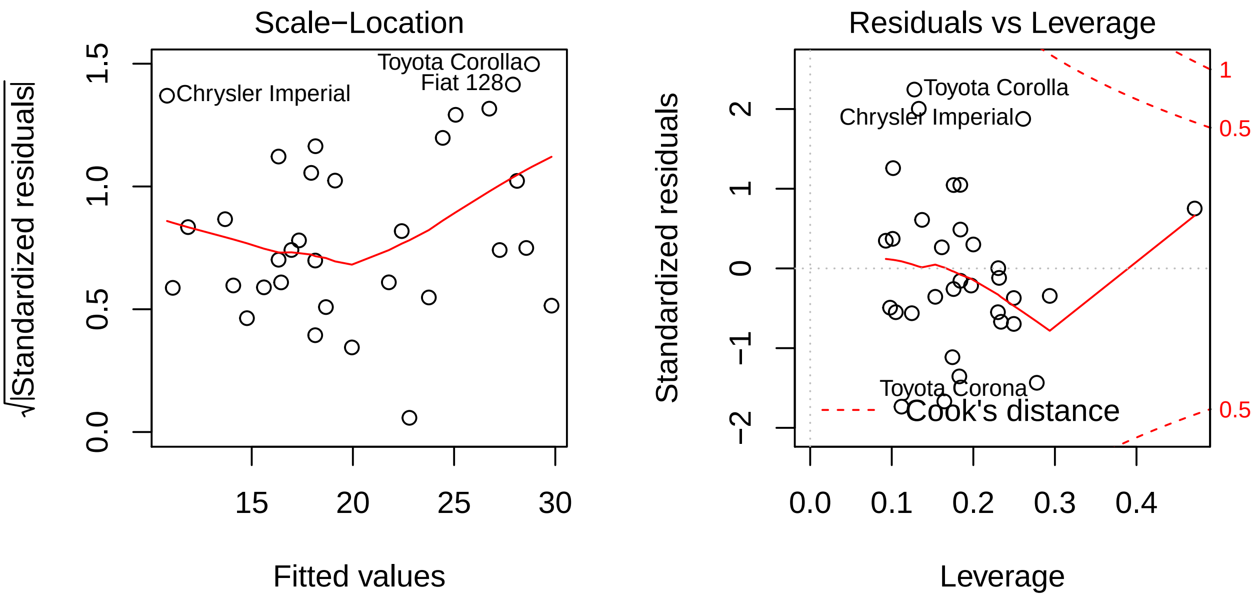
Stepwise Algorithm yeilds a model with 4 variables: cyl, hp, wt, am. Adjusted R-squared of 84% is significantly larger than that of the simple model (with am as only predictor). This points out that 84 of variability in the data can be explained by the improved model. Variance inflation factor analysis does not reveal abnormally large (more than 10) values, which implies that model does not contain variables with high corelation with each other.

p-values for coefficents are significant except for the cyl8 and am1. The first one implies that there is no significant difference between 6 and 8 cylinder engine cars. The second one says there is no difference between gear types.

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ cyl + hp + wt + am
## Model 3: mpg ~ cyl + disp + hp + drat + wt + qsec + vs + am + gear + carb
##   Res.Df    RSS Df Sum of Sq       F    Pr(>F)
## 1     30 720.90
## 2     26 151.03  4    569.87 17.7489 1.476e-05 ***
## 3     15 120.40 11     30.62  0.3468    0.9588
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Anova points out that the stepwise model's variables are a significant (p-value less than 0.001) improvement over the simple model, while full model does not give significant improvement over the mdlstep





Residuals plots do not express any non-random pattern which implies that what little variance is left in the model is normally random and unpredictable.
Standardised residuals are situated close to the normal line on Q-Q plot, another indication that model leftover variance is random normal.
Cook's distance plot does not reveal any extreme data that may influence the model in a game-changing way.

Conclusion

In this study we have proposed a model which tackles an amount of influence which different cars parameters exert on fuel consumption. A stepwise selection algorithm gave us a model with 4 main influencing parameters: number of cylinders (cyl), horsepower (hp), weight (wt) and gearbox type (am). While all the parameters are significant (having low p-value), the transmission type is not, which means that the model we created can not provide us with definitive answer to the questions asked in assignment.

Nevertheless, suppose the coefficent was sufficiently significant, what would have been the answers to the questions then? 1. "Is an automatic or manual transmission better for MPG"
am1 coefficent is positive, meaning that the manual transmission vehicles travel more miles on one gallon of fuel, so the manual transmission is better than automatic.
2. "Quantify the MPG difference between automatic and manual transmissions"
am1 coefficent is 1.8, so the manual transmission vehicles travel 1.8 miles more than automatic transmission vehicles on one gallon of fuel.