Regression Models

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May 17, 2020

Overview

By looking at a data set of a collection of cars we are interested in exploring the relationship between a set of variables and miles per gallon. In particularly the following two questions:

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

The following steps are followed

- Data Processing
- Data Exploration of variables Transmission and MPG
- Model selection by trying out different models
- Model validation
- Final conclusions on results observed

Data Processing

Changing am and cylinders to factors

```
library(ggplot2)
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following object is masked from 'package:GGally':
##
##     nasa

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggfortify)

data(mtcars)

```

```
mtcarsFactors <- mtcars
mtcarsFactors$am <- as.factor(mtcarsFactors$am)
levels(mtcarsFactors$am) <- c("automatic", "manual")

mtcarsFactors$cyl <- as.factor(mtcarsFactors$cyl)
mtcarsFactors$gear <- as.factor(mtcarsFactors$gear)
mtcarsFactors$vs <- as.factor(mtcarsFactors$vs)
levels(mtcarsFactors$vs) <- c("V", "S")
```

Exploratory data analyses

Basic Data summary

```
# Res 1
dim(mtcarsFactors)
```

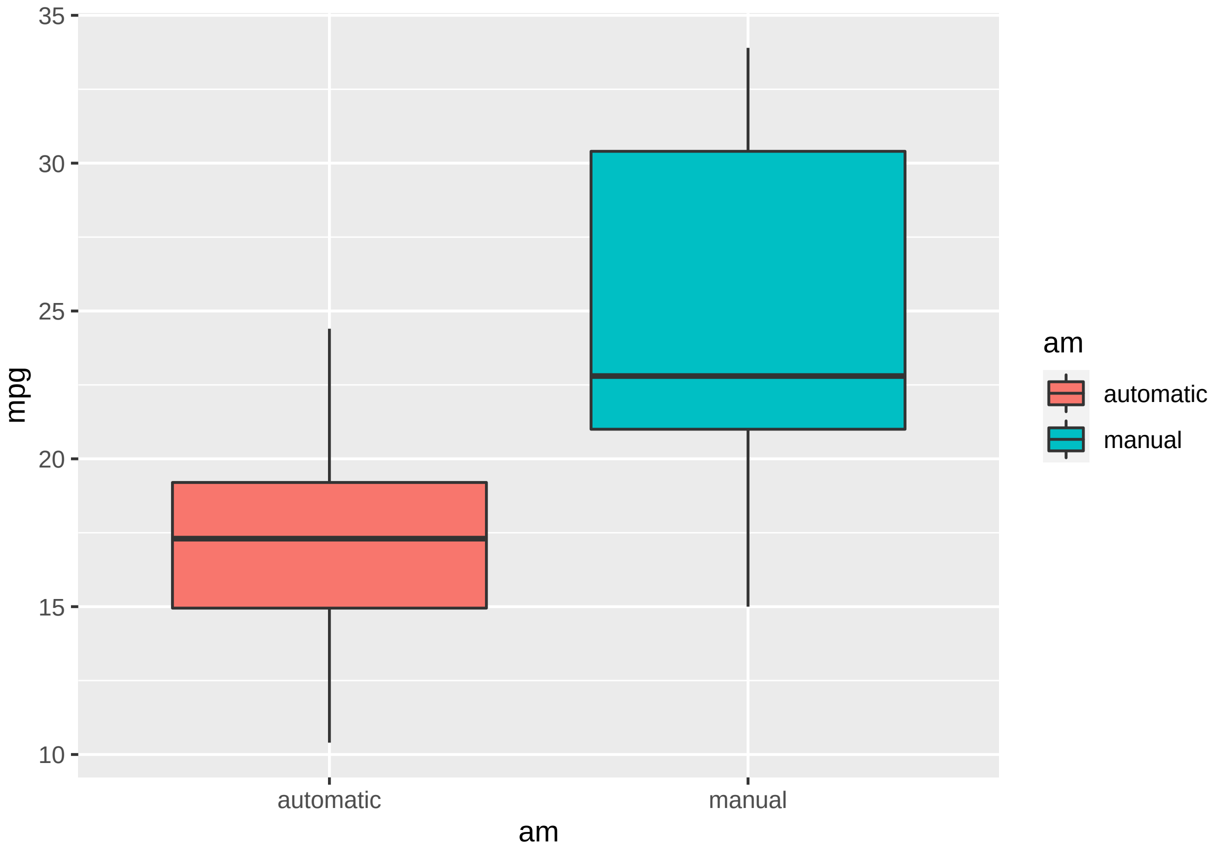
```
## [1] 32 11
```

```
# Res 2
head(mtcarsFactors)
```

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

Relation between parameters of interest

```
# Figure 1
library(ggplot2)
p <- ggplot(mtcarsFactors, aes(am, mpg))
p + geom_boxplot(aes(fill = am))
```



Observation: The manual transmissions have higher mpg's.

Correlations of all the other variables are observed to include those with correlation higher than am

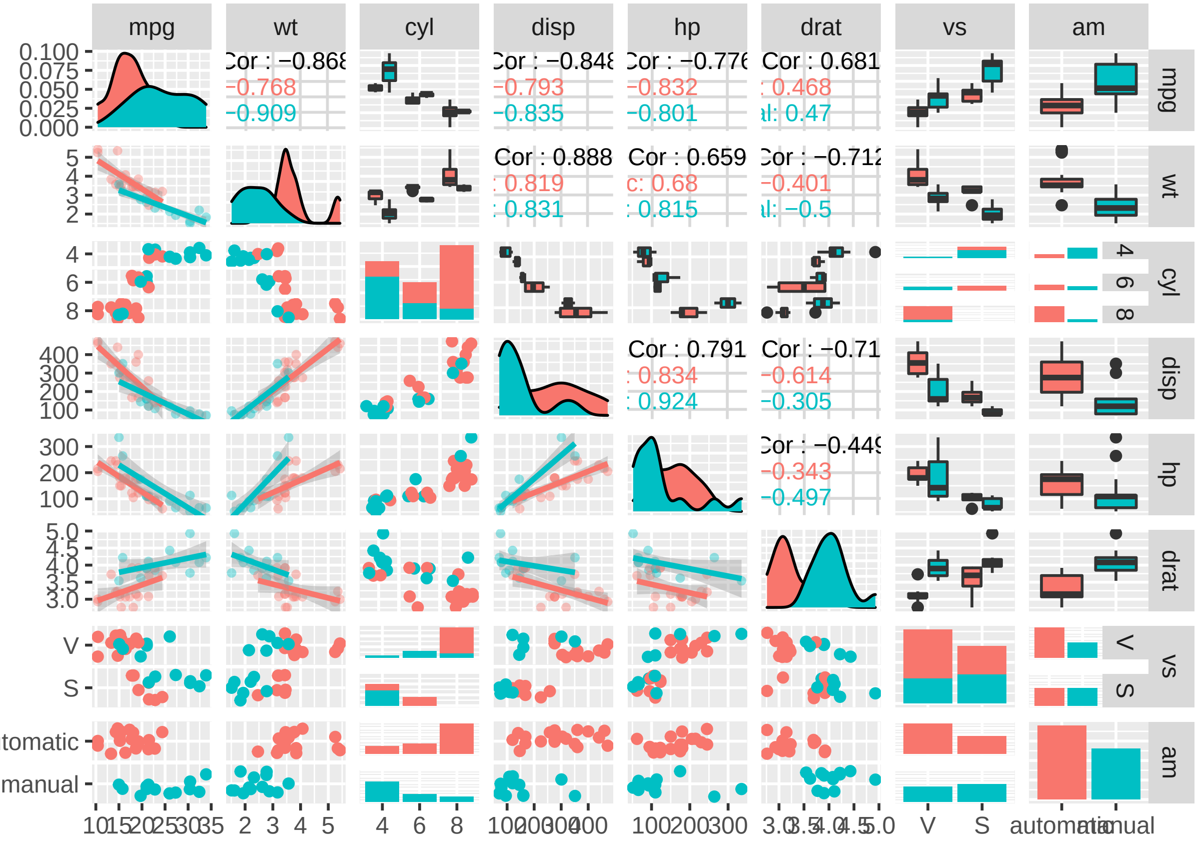
```
# Res 3
cors <- cor(mtcars$mpg, mtcars)
orderedCors <- cors[,order(-abs(cors[1,]))]
orderedCors
```

```
##        mpg         wt        cyl       disp         hp       drat         vs
##  1.0000000 -0.8676594 -0.8521620 -0.8475514 -0.7761684  0.6811719  0.6640389
##         am       carb       gear       qsec
##  0.5998324 -0.5509251  0.4802848  0.4186840
```

```
# Res 4
amPos <- which(names(orderedCors)=="am")
subsetColumns <- names(orderedCors)[1:amPos]
subsetColumns
```

```
## [1] "mpg"  "wt"   "cyl"  "disp" "hp"   "drat" "vs"   "am"
```

```
# Figure 2
mtcarsFactors[,subsetColumns] %>%
   ggpairs(
     mapping = ggplot2::aes(color = am),
     upper = list(continuous = wrap("cor", size = 3)),
     lower = list(continuous = wrap("smooth", alpha=0.4, size=1), combo = wrap("dot"))
   )
```



Model selection

Observation : Many variables have strong correlation other than am.

Need to include these variables to have an accurate model

Basic Model

```
# Res 5
basicFit <- lm(mpg ~ am, mtcarsFactors)
summary(basicFit)
```

```
##
## Call:
## lm(formula = mpg ~ am, data = mtcarsFactors)
##
## 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 ***
## ammanual       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
```

Observation: P Value is low, Rsquared is also not satisfactory

Including all the variables in the model

```
# Res 6
totalFit <- lm(mpg ~ ., mtcarsFactors)
summary(totalFit)
```

```
##
## Call:
## lm(formula = mpg ~ ., data = mtcarsFactors)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.2015 -1.2319  0.1033  1.1953  4.3085
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 15.09262   17.13627   0.881   0.3895
## cyl6        -1.19940    2.38736  -0.502   0.6212
## cyl8         3.05492    4.82987   0.633   0.5346
## disp         0.01257    0.01774   0.708   0.4873
## hp          -0.05712    0.03175  -1.799   0.0879 .
## drat         0.73577    1.98461   0.371   0.7149
## wt          -3.54512    1.90895  -1.857   0.0789 .
## qsec         0.76801    0.75222   1.021   0.3201
## vsS          2.48849    2.54015   0.980   0.3396
## ammanual     3.34736    2.28948   1.462   0.1601
## gear4       -0.99922    2.94658  -0.339   0.7382
## gear5        1.06455    3.02730   0.352   0.7290
## carb         0.78703    1.03599   0.760   0.4568
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.616 on 19 degrees of freedom
## Multiple R-squared:  0.8845, Adjusted R-squared:  0.8116
## F-statistic: 12.13 on 12 and 19 DF,  p-value: 1.764e-06
```

Observation:Rsquared value is improved. P value doesn't show any significance

Trying StepWise Regression

```
# Res 7
bestFit <- step(totalFit,direction="both",trace=FALSE)
summary(bestFit)
```

```
##
## Call:
## lm(formula = mpg ~ wt + qsec + am, data = mtcarsFactors)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4811 -1.5555 -0.7257  1.4110  4.6610
##
## Coefficients:
```

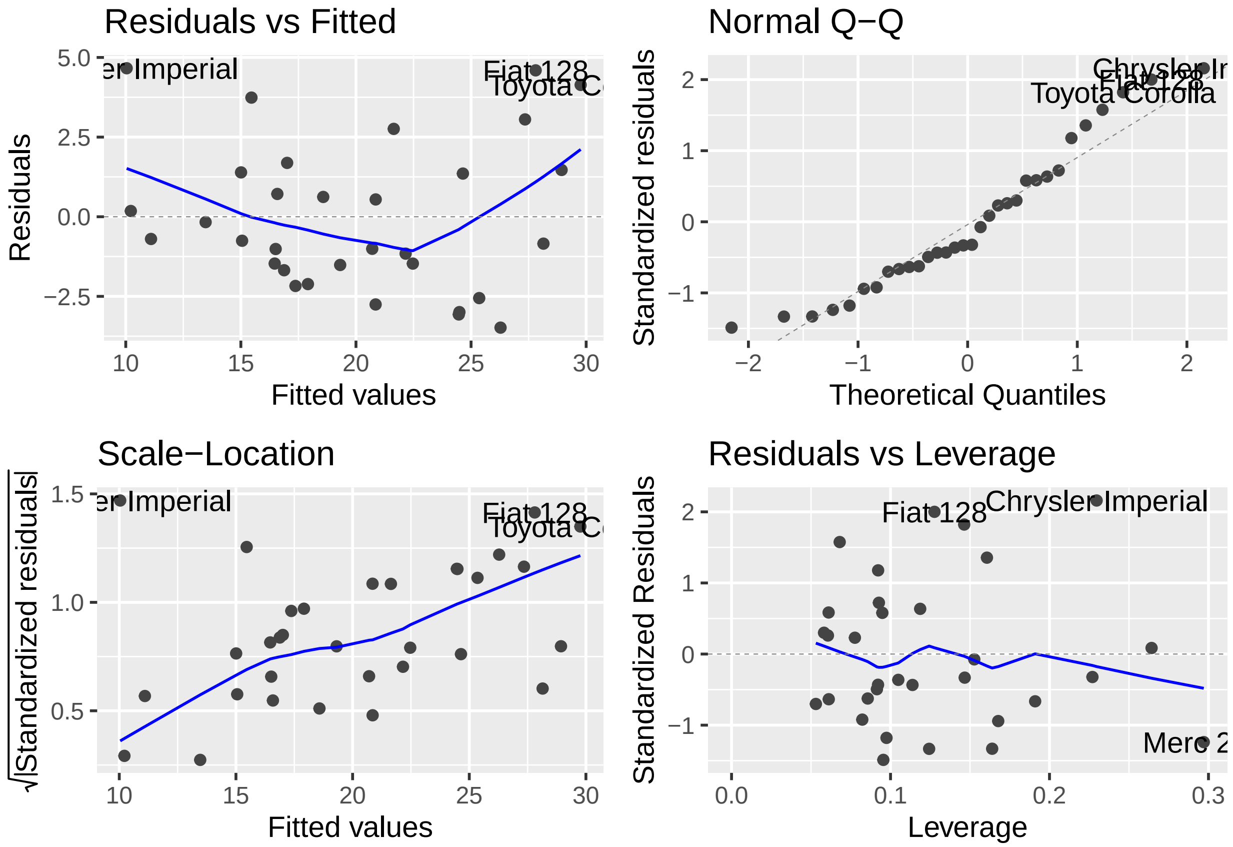
```
##              Estimate Std. Error t value Pr(>|t|)    
## (Intercept)    9.6178     6.9596   1.382 0.177915    
## wt            -3.9165     0.7112  -5.507 6.95e-06 ***
## qsec           1.2259     0.2887   4.247 0.000216 ***
## ammanual       2.9358     1.4109   2.081 0.046716 *  
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 2.459 on 28 degrees of freedom
## Multiple R-squared:  0.8497, Adjusted R-squared:  0.8336 
## F-statistic: 52.75 on 3 and 28 DF,  p-value: 1.21e-11
```

Model examination

The best model resulting from Step wise Regression is `mpg ~ wt + qsec + am` P Values are significant for all the 3 variables Rsquared is also high

Investigating Residuals Vs fitted

```r
# Figure 3
autoplot(bestFit)
```



Observation: ‘Normal Q-Q’ plot is good, but the ‘Residuals vs Fitted’ and ‘Scale-Location’ are not satisfactory

Conclusion

Question : “Is an automatic or manual transmission better for MPG” All the models experimented explain manual transmission will increase your MPG holding all other paramters constant

Question : "Quantify the MPG difference between automatic and manual transmissions" Manual transmission has 3 miles per gallon more than automatic. This is based on the result from the best fit model `mpg ~ wt + qsec + am` with p value <0.05 and Rsquared $= 0.85$

Other Observation : Model is not accurate as suggested by Residuals Vs. Fit plot This ight be due to lower number of observations (32) in the data

Though it can be said Manual Transmissions gives 3 MPG more than Automatic. I might not be accurate for any of the future data.