Intelligent Data Analysis - Homework 1.1

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1 Introduction

We have chosen the Mileage dataset, it contains data about the fuel consumption of different car manufacturers which had a new release every year between 1999 and 2008. The dataset contains 234 records of 11 different variables, which are:

- **Displ:** engine displacement or cylinder admission volume in liters, quantitative variable.

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1,6	2,4	3,3	3,472	4,6	7

- **Cty:** city mileage in miles per gallon, quantitative variable.

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
9	14	17	16,83	19	35

- **Hwy:** highway mileage in miles per gallon, quantitative variable.

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
12	18	24	23,39	27	44

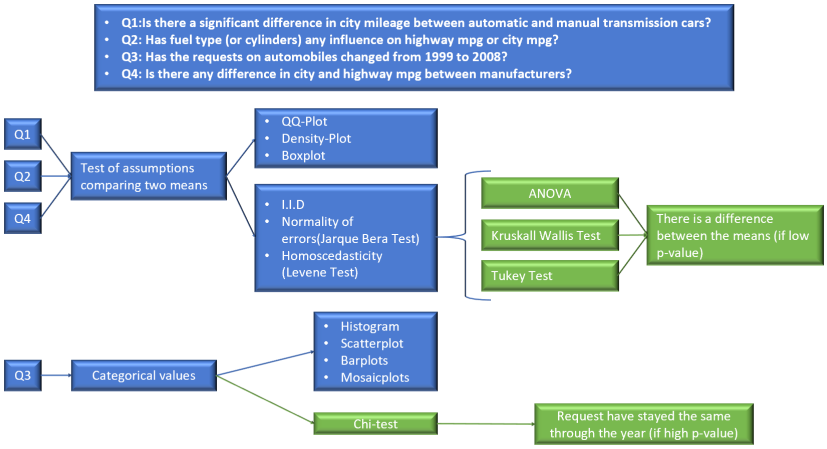
- **Manufacturer:** car manufacturer, categorical variable.
- **Year:** year of manufacturing (1999 or 2008), categorical variable.
- **Class:** vehicle class, categorical variable
- **Cyl:** number of cylinders, categorical variable.
- **Model:** car model name (38 different models), categorical variable.
- **Trans:** type of transmission (automatic or manual), categorical variable.
- **Dvr:** drive type (front wheel, rear wheel, 4 wheel), categorical variable.
- **Fl:** fuel type (petrol, diesel electric, ethanol, regular), categorical variable.

2 Questions and data analysis plan

For this homework 1.1, we have decided to create a shiny dashboard application that allowed us to express our analysis in a more convenient way. We have included our results of the statistical tests for every question under each plot in the application.

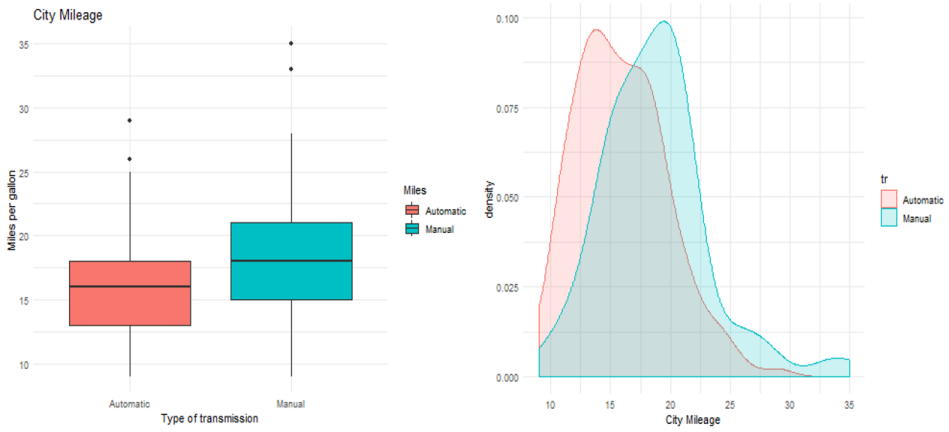
2.1 Data Analysis Plan

The following is the scheme of the data analysis plan we have followed:



2.2 Q1, Is there a significant difference in City / Highway mileage or in Engine Displacement between automatic and manual transmission cars?

This question is divided in three parts depending on the three variables we are analyzing: city mileage, highway mileage and engine displacement. The following is the example for City mileage:



The analysis is done with a new variable that differs between automatic and manual cars. The objective is to determine whether the mean between both populations is equal.

In order to test if there is a difference between the means, we have proposed to use One-Way ANOVA. Previously, we have tested if the variables fulfill some assumptions: Normality of errors and Homoscedasticity (as we have assumed the variables are i.i.d). To achieve this, we have used Jarque Bera and Levene tests, respectively.

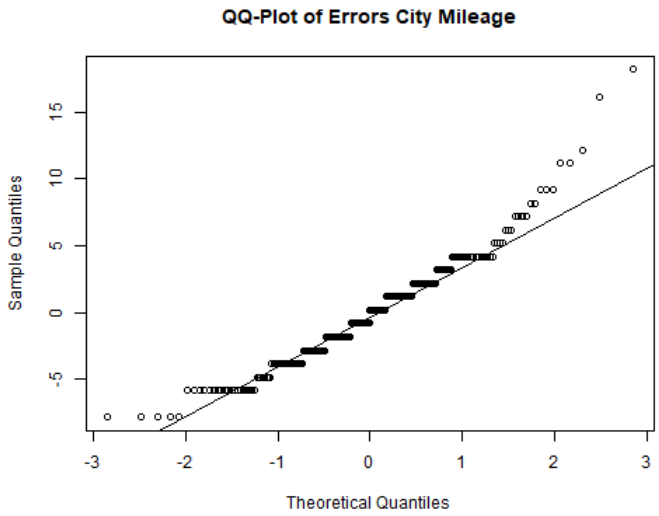
In case the assumptions above are met, we have selected the One-Way ANOVA test. Otherwise, we have applied the non-parametric Kruskall-Wallis test. There is also an option of performing the whole process removing the outliers from the City Mileage Data.

The results of Jarque Bera test and Levene test are the following:

```
Jarque Bera Test
X-squared = 48.448, df = 2, p-value = 3.018e-11

Levene Test
Test Statistic = 0.3209, p-value = 0.5716
```

Due to the low value of p-value in the Jarque Bera test, we can reject the null hypothesis about the normality of the errors. Also, we can confirm this by observing the following QQ plot:



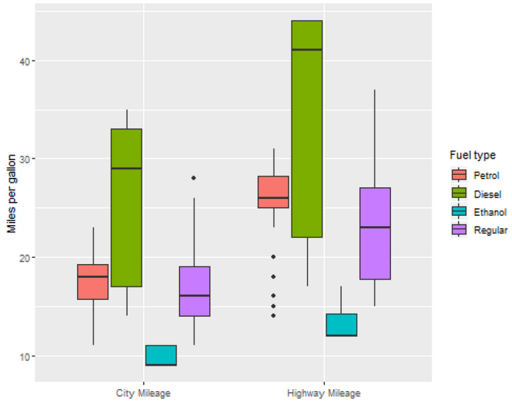
At this point, we apply Kruskall-Wallis test instead of ANOVA:

```
Kruskal-Wallis
chi-squared = 21.988, df = 1, p-value = 2.743e-06
```

By obtaining a low value very close to zero as the p-value above, we can reject again the null hypothesis that the distribution of the means for automatic and manual transmission are similar. There is also a possibility of repeat the process with the log of the data in the shiny app.

2.3 Q2, Has fuel type (or cylinders) any influence on highway mpg or city mpg?

For this question we have created Boxplots comparing the City Mileage to the Highway Mileage with respect to the fuel type of each automobile and the number of cylinders each automobile has. Here is the example of the fuel type:



The boxplot above shows that each type of fuel represents a different amount of variation in the miles per gallon variable, so we can observe that there is much overlap of values between some types of fuel such as Petrol, Diesel and Regular. Thus, differences in the means could be produced by chance. At this point we can use ANOVA to compare the variation among samples with the ones within groups.

Df	Sum Sq	Mean Sq	F value	Pr(>F)
Fl	3	802	267.3	18.18	1.29e−10 ***
Residuals	229	3367	14.7	

Signif. **codes**: 0 *** 0.001 ** 0.01 * 0.05 . 0.1 1

By obtaining low F value and p-value we can accept the alternative hypothesis that there is a significant relationship between the fuel type and miles per gallon.

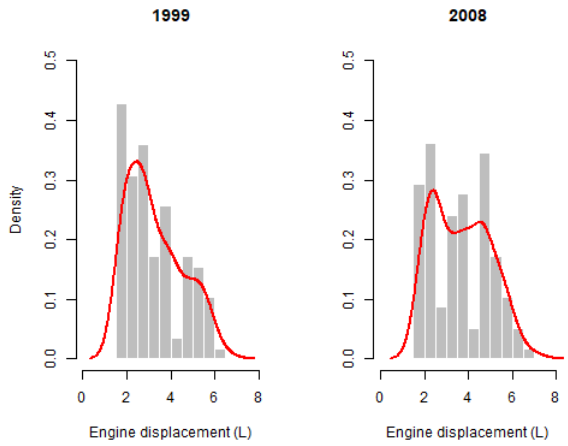
However, with ANOVA we only know that not all the means are equal but not which groups are different from the others. To achieve this we can apply the Tukey test:

	diff	lwr	upr	p adj
e–d	−15.8500000	−21.507492	−10.1925081	0.0000000
p–d	−8.2346154	−12.881191	−3.5880397	0.0000438
r–d	−8.8619048	−13.365566	−4.3582440	0.0000044
p–e	7.6153846	3.846514	11.3842552	0.0000023
r–e	6.9880952	3.396900	10.5792900	0.0000057
r–p	−0.6272894	−2.202132	0.9475537	0.7315324

With the table above, we can conclude that there is a significant difference in the miles per gallon between all types of fuels but petrol and ethanol.

2.4 Q3, Is there any difference in car requests between the years 1999 and 2008?

For this question we compared the distribution of some of the variables in years 1999 and 2008 in order to determine whether the requests on automobiles have been changed. On the histogram plot we compare the distribution of the engine displacement for each automotive through the years.



As we can observed in the histogram above, in 2008 seems to be a growing demand on vehicles with higher engine displacement. We have used a reactive bar chart to visualize how the different levels of the categorical variables are distributed between 1999 and 2008.

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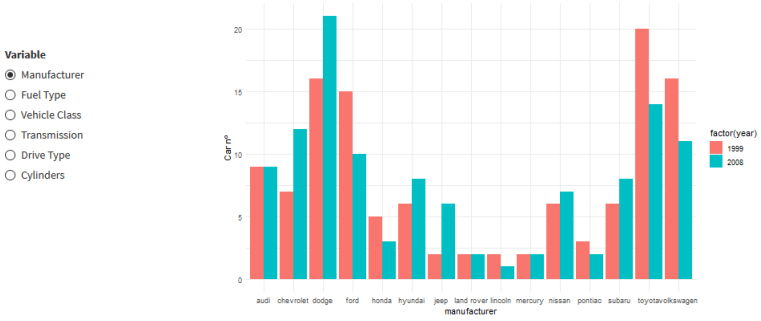
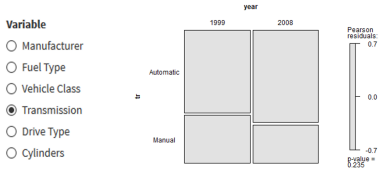
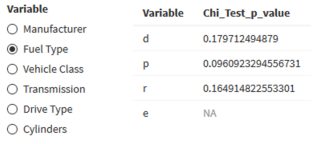


In addition, we include a mosaic plot for each of the categorial variables showing in the list below and the categorical variable of the year. By using this plot, we can observe a pair of highlighted facts:

- The use of ethanol has appeared as a strong option as fuel type.
- It seems to be a reasonable tendency of displacement of manual transmission for automatic one.
- It might be a slightly tendency of stop using front-wheel drive type.
- The use of five cylinders in the engine has started to be strongly considered.

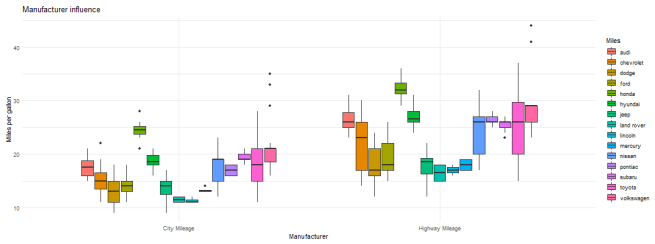
We have included a reactive chi-square test for each categorical variable in the list below and the categorical variable of the year. Given that none of the p-values obtained are lower than the significance level of 0.05, we cannot reject the null hypothesis of non-independence between the variables, therefore, we cannot conclude if the variables are related to each other or not.





2.5 Q4, Is there any difference in city and highway mpg between manufacturers?

For this question we have used a double box plot to show how the different manufacturers engines behave in terms of consumption for City driving and Highway driving. The tests used are similar as the used in the previous questions (see the shiny app):



In order to test if there is a difference between the means, we propose to use One-Way ANOVA as in Q2. Previously, we have tested again if the variables fulfill some assumptions: Normality of errors and Homocedasticity (using Jarque Bera and Levene tests), respectively. The results of Jarque Bera test and Levene test are the following:

```
 Jarque Bera Test
X-squared = 48.448, df = 2, p-value = 3.018e-11
```

```
Levene Test
Test Statistic = 2.7775, p-value = 0.000806
```

Due to the low value of p-value in the Jarque Bera test and checking the qq-plot in the shiny app, we can reject the null hypothesis about the normality of the errors. Then we apply Kruskall-Wallis test instead of ANOVA:

```
Kruskal-Wallis
chi-squared = 141.14, df = 14, p-value < 2.2e-16
```

By obtaining a low value very closed to zero as p-value with the test above, we can reject again the null hypothesis that the distribution of the means in the behavior of manufacturers in both city and highway is similar.