Analysis and Prediction Model of Fuel Consumption and Carbon Dioxide Emissions of electric vehicle

Presented by,

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Content

Abstract

- Due to the alarming rate of climate change, fuel consumption and emission estimates are critical in determining the effects of materials and stringent emission control strategies. In this research, an analytical and predictive study has been conducted using the Government of 2022 fuel consumption rating, delivering a comparative view of different brands and vehicle models by their fuel consumption and carbon dioxide emissions.
- LinearRegression, DecisionTreeRefressor and RandomForestRegressor model are the best model for predictions from one vehicle feature input, with up to 97% accuracy.

About Dataset

- This dataset captures the details of how CO2 emissions by a vehicle can vary with the different features. The dataset has been taken from government of 2022 fuel consumption rating.
  There are total 946 rows and 15 columns. There are few abbreviations that has been used to describe the features. I am listing them out here. The same can be found in the Data Description sheet.

Model

4WD/4X4 = Four-wheel drive
AWD = All-wheel drive
FFV = Flexible-fuel vehicle
SWB = Short wheelbase
LWB = Long wheelbase
EWB = Extended wheelbase

Transmission

A = Automatic
AM = Automated manual
AS = Automatic with select shift
AV = Continuously variable
M = Manual
3 - 10 = Number of gears

Fuel type

X = Regular gasoline
Z = Premium gasoline
D = Diesel
E = Ethanol (E85)
N = Natural gas

Fuel Consumption

City and highway fuel consumption ratings are shown in litres per 100 kilometres (L/100 km) - the combined rating (55% city, 45% hwy) is shown in L/100 km and in miles per gallon (mpg)

CO2 Emissions

The tailpipe emissions of carbon dioxide (in grams per kilometre) for combined city and highway driving

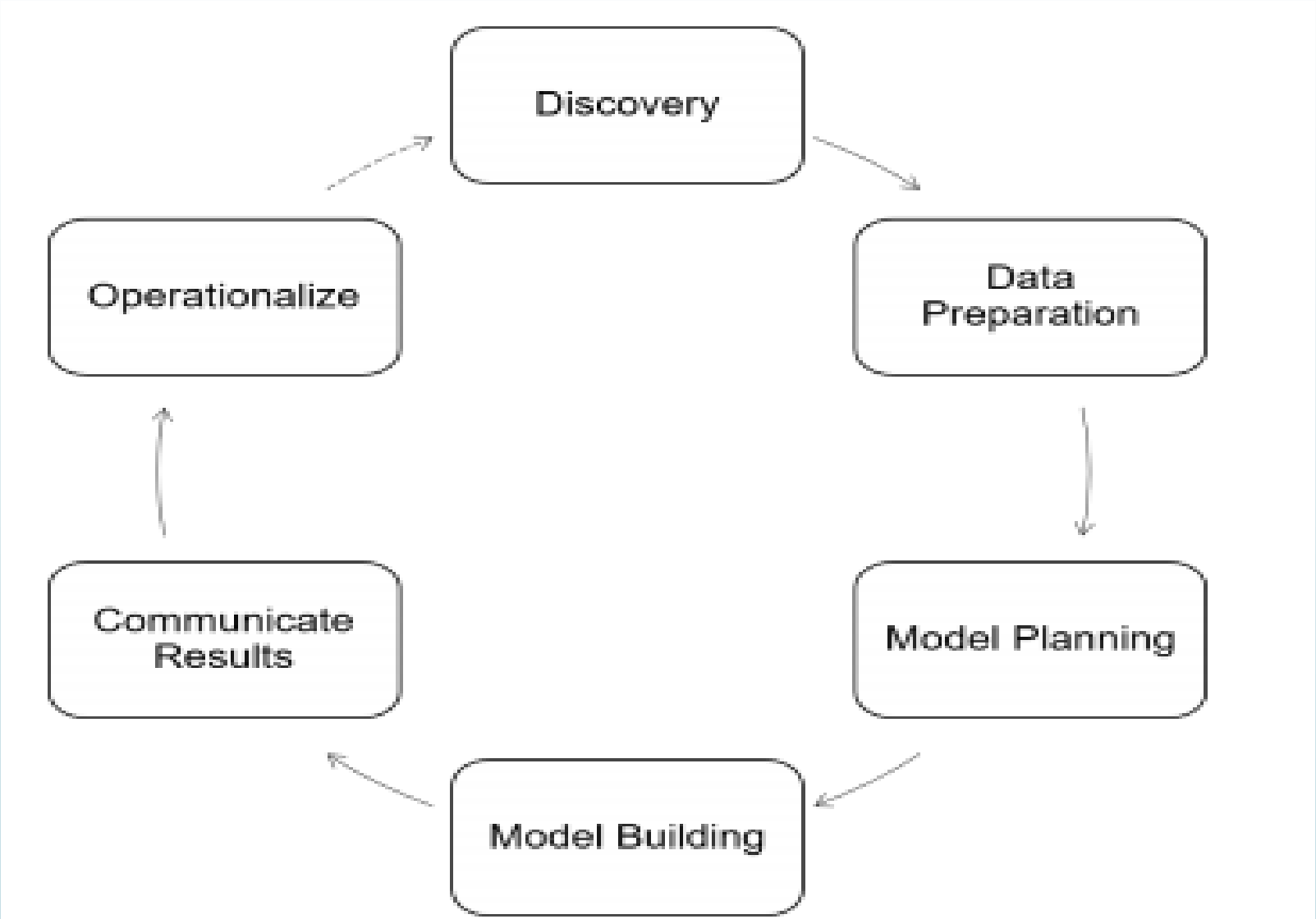
Fuel Consumption dataset

	Model Year	Make	Model	Vehicle Class	Engine Size(L)	Cylinders	Transmission	Fuel Type	Fuel Consumption (City (L/100 km)	Fuel Consumption(Hwy (L/100 km))	Fuel Consumption(Comb (L/100 km))	Fuel Consumption(Comb (mpg))	CO2 Emissions(g/km)	CO2 Rating	Smog Rating
0	2022	Acura	ILX	Compact	2.4	4	AM8	Z	9.9	7.0	8.6	33	200	6	3
1	2022	Acura	MDX SH-AWD	SUV: Small	3.5	6	AS10	Z	12.6	9.4	11.2	25	263	4	5
2	2022	Acura	RDX SH-AWD	SUV: Small	2.0	4	AS10	Z	11.0	8.6	9.9	29	232	5	6
3	2022	Acura	RDX SH-AWD A-SPEC	SUV: Small	2.0	4	AS10	Z	11.3	9.1	10.3	27	242	5	6
4	2022	Acura	TLX SH-AWD	Compact	2.0	4	AS10	Z	11.2	8.0	9.8	29	230	5	7
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
941	2022	Volvo	XC40 T5 AWD	SUV: Small	2.0	4	AS8	Z	10.7	7.7	9.4	30	219	5	5
942	2022	Volvo	XC60 B5 AWD	SUV: Small	2.0	4	AS8	Z	10.5	8.1	9.4	30	219	5	5
943	2022	Volvo	XC60 B6 AWD	SUV: Small	2.0	4	AS8	Z	11.0	8.7	9.9	29	232	5	7
944	2022	Volvo	XC90 T5 AWD	SUV: Standard	2.0	4	AS8	Z	11.5	8.4	10.1	28	236	5	5
945	2022	Volvo	XC90 T6 AWD	SUV: Standard	2.0	4	AS8	Z	12.4	8.9	10.8	26	252	5	7

946 rows × 15 columns

Methodology

Macro Methodology



Micro Methodology

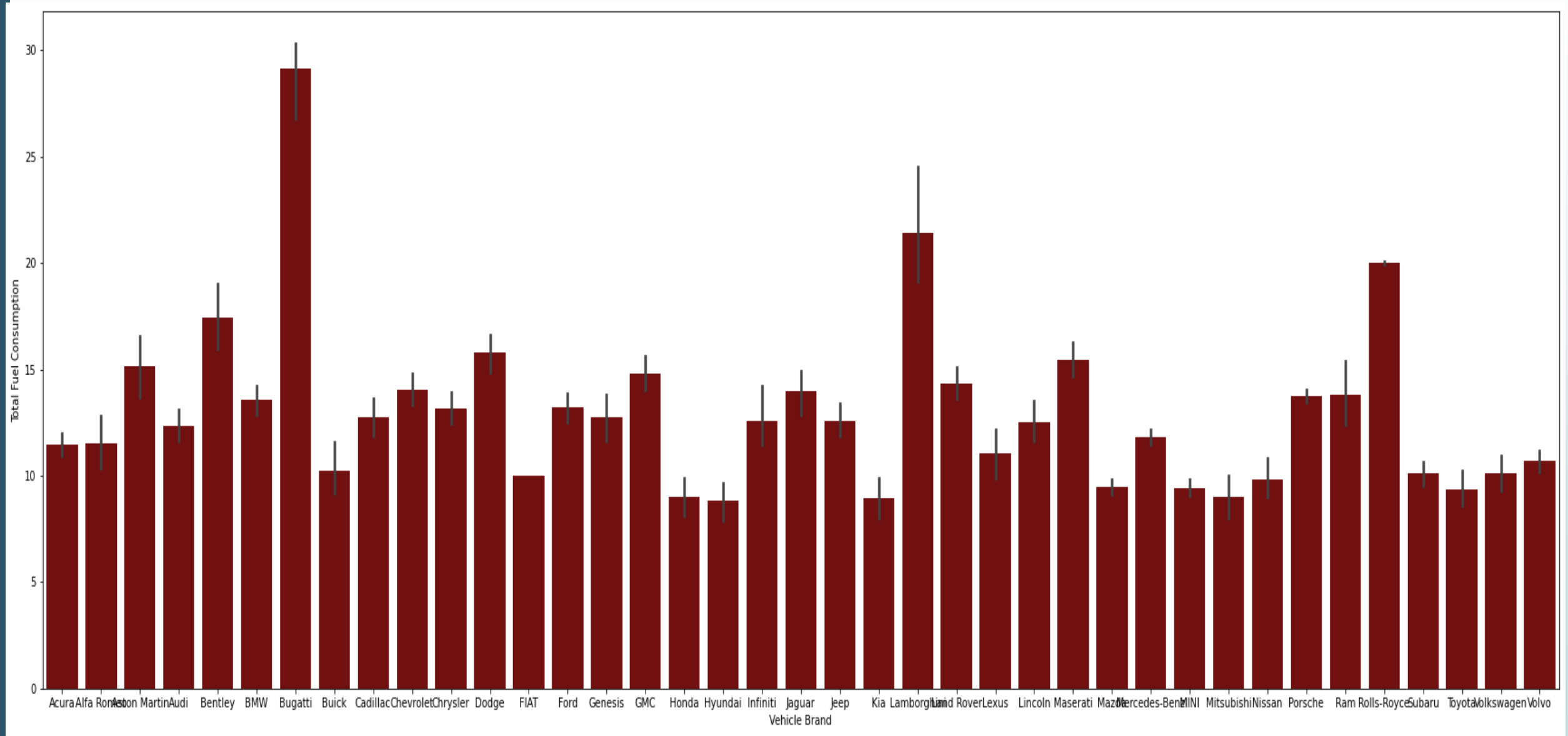
Level 1: Descriptive Statistics

- This level comprises basic calculations of central tendency (mean, median, mode) and dispersion statistics (standard deviation, variance, range). A list of comparative statistics of fuel consumption and CO2 emission has been presented for each brand, model, engine size, vehicle class, transmission and cylinder type, and fuel type, giving a comprehensive outlook of emissions and consumption of various vehicle types and brands. The changes Of the patterns through the years are also indicated before progressing to time-series changes of the greenest and the least environmental-friendly vehicle brand.

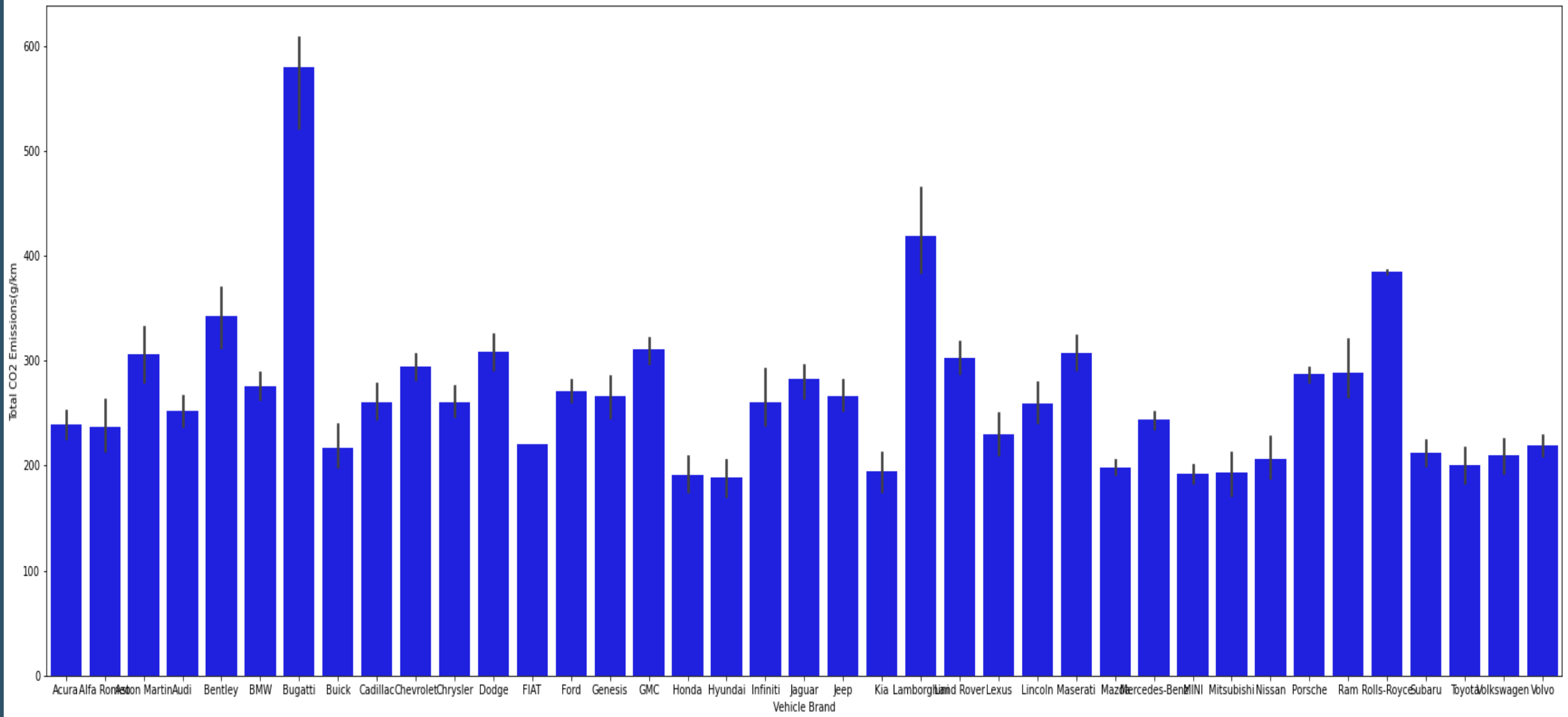
```
fuel_data.describe()
```

	Model Year	Engine Size(L)	Cylinders	Fuel Consumption (City (L/100 km)	Fuel Consumption(Hwy (L/100 km))	Fuel Consumption(Comb (L/100 km))	Fuel Consumption(Comb (mpg))	CO2 Emissions(g/km)	CO2 Rating	Smog Rating
count	946.0	946.000000	946.000000	946.000000	946.000000	946.000000	946.000000	946.000000	946.000000	946.000000
mean	2022.0	3.198732	5.668076	12.506448	9.363319	11.092072	27.247357	259.172304	4.539112	4.950317
std	0.0	1.374814	1.932670	3.452043	2.285125	2.876276	7.685217	64.443149	1.471799	1.679842
min	2022.0	1.200000	3.000000	4.000000	3.900000	4.000000	11.000000	94.000000	1.000000	1.000000
25%	2022.0	2.000000	4.000000	10.200000	7.700000	9.100000	22.000000	213.250000	3.000000	3.000000
50%	2022.0	3.000000	6.000000	12.200000	9.200000	10.800000	26.000000	257.000000	5.000000	5.000000
75%	2022.0	3.800000	6.000000	14.700000	10.700000	12.900000	31.000000	300.750000	5.000000	6.000000
max	2022.0	8.000000	16.000000	30.300000	20.900000	26.100000	71.000000	608.000000	10.000000	7.000000

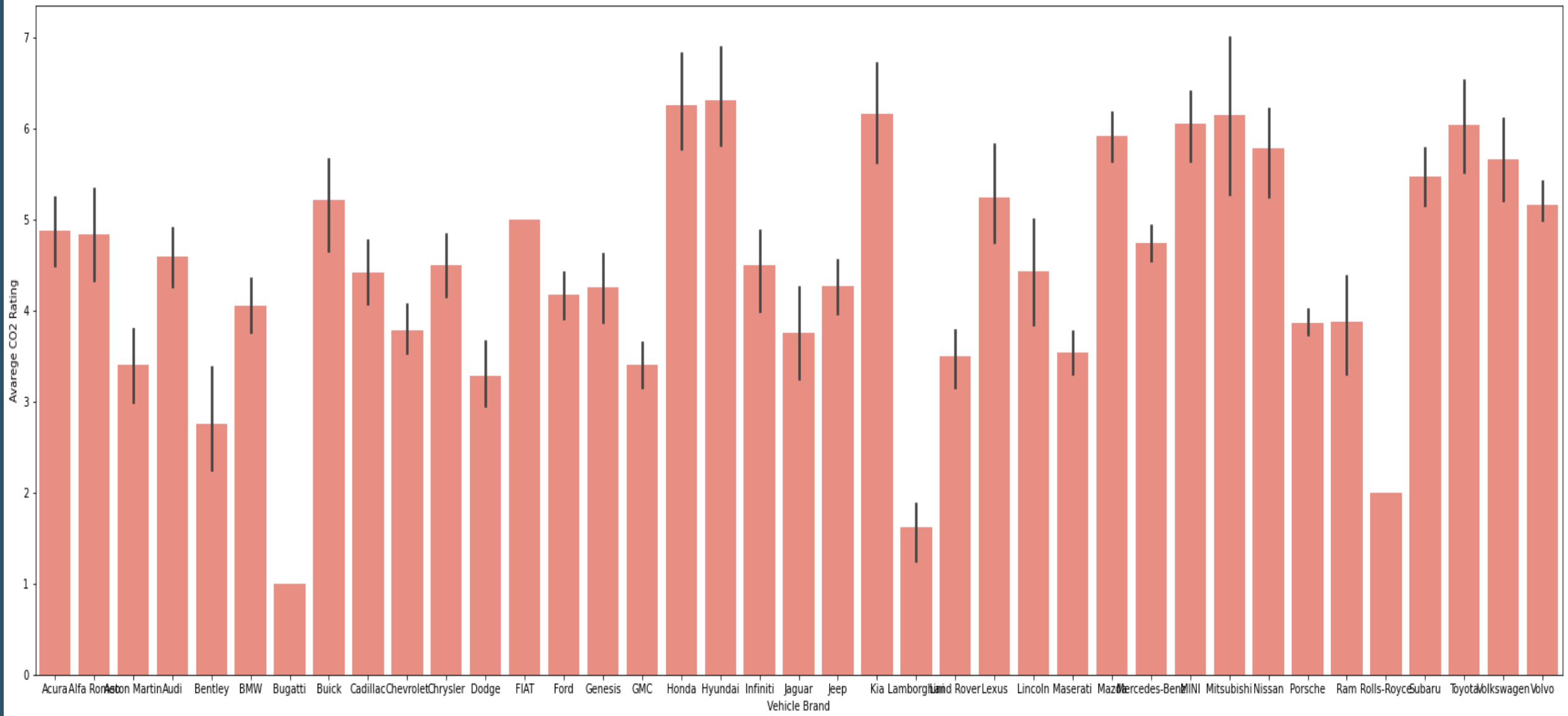
Total fuel consumption(L/100 km) of each brand



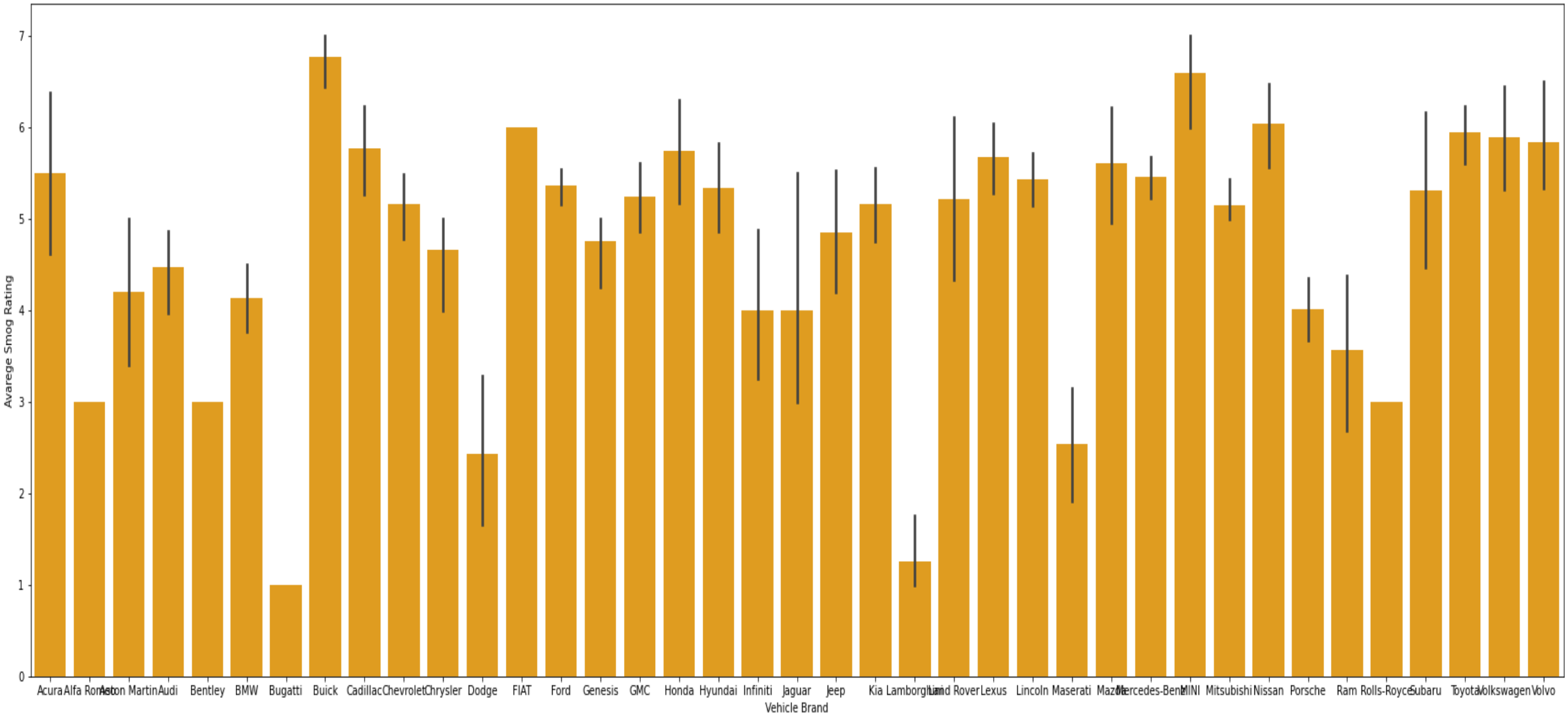
CO2 emission(g/km) of each brand



CO2 rating of each brand



Smog rating of each brand



Level 2: Inferential Statistics

t-Test

a two-tailed *T*-test has been conducted to compare the means of fuel consumption in the city and on the highway for the same vehicle, with the following configurations.

• Null Hypothesis (H0): mean of fuel consumption in the city = mean of fuel consumption on a highway;

• Alternative Hypothesis (Ha): mean of fuel consumption in a city *6 is not eqal to* mean of fuel consumption in highway;

```
fuel_data['Fuel Consumption (City (L/100 km)'].mean()
```

```
12.506448202959833
```

```
fuel_data['Fuel Consumption(Hwy (L/100 km))'].mean()
```

```
9.363319238900631
```

```
fuel_data[['Fuel Consumption (City (L/100 km)','Fuel Consumption(Hwy (L/100 km))']].describe()
```

	Fuel Consumption (City (L/100 km)	Fuel Consumption(Hwy (L/100 km))
count	946.000000	946.000000
mean	12.506448	9.363319
std	3.452043	2.285125
min	4.000000	3.900000
25%	10.200000	7.700000
50%	12.200000	9.200000
75%	14.700000	10.700000
max	30.300000	20.900000

Correlation

```
fuel_data.drop(['Model Year'], axis = 1).corr()
```

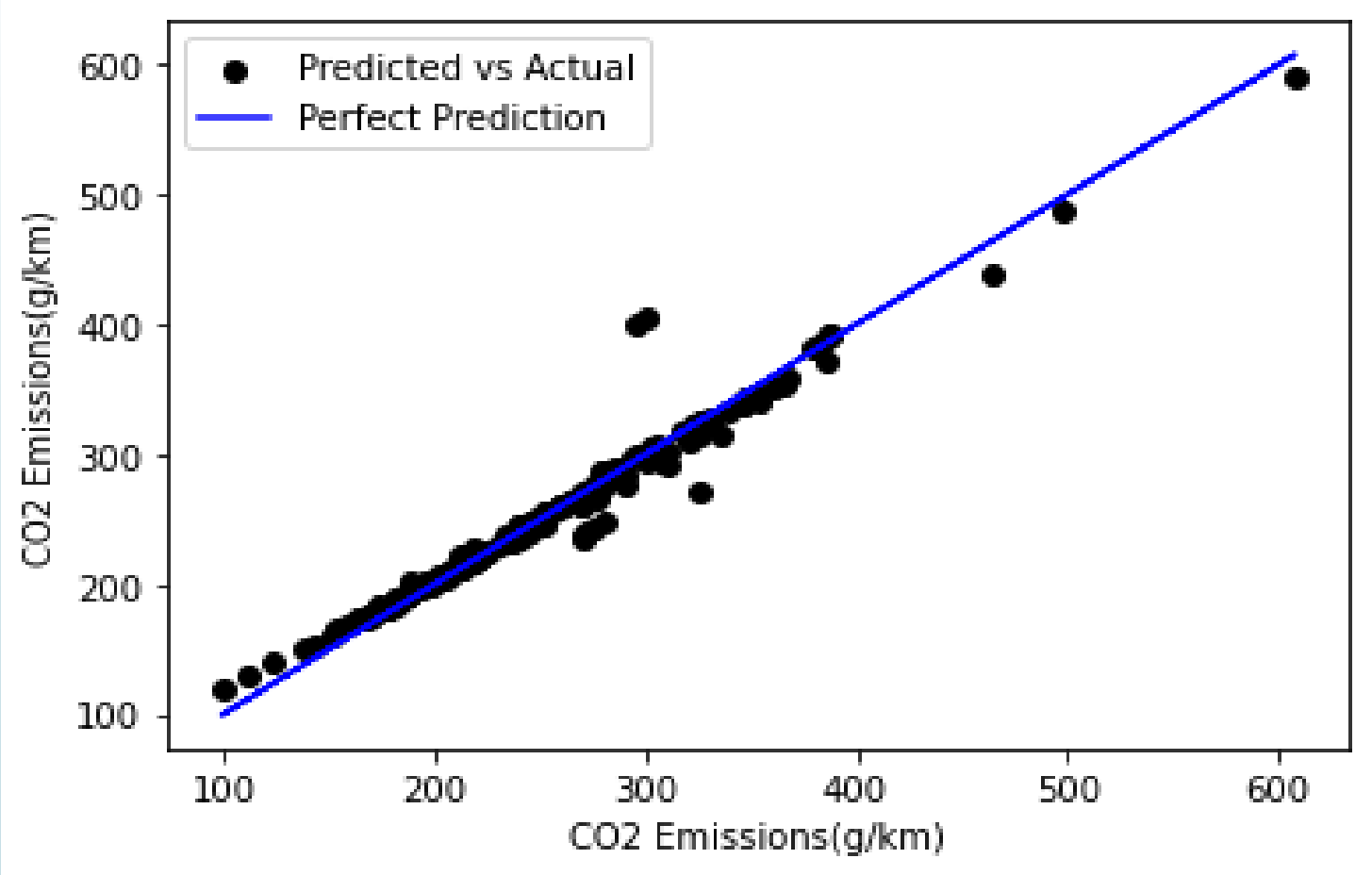
	Engine Size(L)	Cylinders	Fuel Consumption (City (L/100 km)	Fuel Consumption(Hwy (L/100 km))	Fuel Consumption(Comb (L/100 km))	Fuel Consumption(Comb (mpg))	CO2 Emissions(g/km)	CO2 Rating	Smog Rating
Engine Size(L)	1.000000	0.920698	0.834925	0.749374	0.818694	-0.704163	0.824188	-0.766333	-0.448239
Cylinders	0.920698	1.000000	0.845688	0.737652	0.821718	-0.693594	0.833241	-0.762157	-0.502149
Fuel Consumption (City (L/100 km)	0.834925	0.845688	1.000000	0.922850	0.990321	-0.909477	0.965632	-0.920524	-0.523928
Fuel Consumption(Hwy (L/100 km))	0.749374	0.737652	0.922850	1.000000	0.967138	-0.877531	0.933991	-0.894668	-0.402099
Fuel Consumption(Comb (L/100 km))	0.818694	0.821718	0.990321	0.967138	1.000000	-0.914305	0.971671	-0.927705	-0.490473
Fuel Consumption(Comb (mpg))	-0.704163	-0.693594	-0.909477	-0.877531	-0.914305	1.000000	-0.913019	0.949561	0.473990
CO2 Emissions(g/km)	0.824188	0.833241	0.965632	0.933991	0.971671	-0.913019	1.000000	-0.954593	-0.520437
CO2 Rating	-0.766333	-0.762157	-0.920524	-0.894668	-0.927705	0.949561	-0.954593	1.000000	0.502625
Smog Rating	-0.448239	-0.502149	-0.523928	-0.402099	-0.490473	0.473990	-0.520437	0.502625	1.000000

```
fuel_data.drop(['Model Year'], axis = 1).corr().unstack().sort_values(ascending = False).drop_duplicates()
```

```
Engine Size(L)                          Engine Size(L)                          1.000000
Fuel Consumption (City (L/100 km)       Fuel Consumption(Comb (L/100 km))       0.990321
Fuel Consumption(Comb (L/100 km))       CO2 Emissions(g/km)                     0.971671
                                        Fuel Consumption(Hwy (L/100 km))        0.967138
CO2 Emissions(g/km)                     Fuel Consumption (City (L/100 km)       0.965632
CO2 Rating                              Fuel Consumption(Comb (mpg))            0.949561
Fuel Consumption(Hwy (L/100 km))        CO2 Emissions(g/km)                     0.933991
                                        Fuel Consumption (City (L/100 km)       0.922850
Cylinders                               Engine Size(L)                          0.920698
                                        Fuel Consumption (City (L/100 km)       0.845688
Fuel Consumption (City (L/100 km)       Engine Size(L)                          0.834925
Cylinders                               CO2 Emissions(g/km)                     0.833241
CO2 Emissions(g/km)                     Engine Size(L)                          0.824188
Fuel Consumption(Comb (L/100 km))       Cylinders                               0.821718
Engine Size(L)                          Fuel Consumption(Comb (L/100 km))       0.818694
Fuel Consumption(Hwy (L/100 km))        Engine Size(L)                          0.749374
Cylinders                               Fuel Consumption(Hwy (L/100 km))        0.737652
CO2 Rating                              Smog Rating                             0.502625
Smog Rating                             Fuel Consumption(Comb (mpg))            0.473990
Fuel Consumption(Hwy (L/100 km))        Smog Rating                            -0.402099
Smog Rating                             Engine Size(L)                         -0.448239
Fuel Consumption(Comb (L/100 km))       Smog Rating                            -0.490473
Smog Rating                             Cylinders                              -0.502149
CO2 Emissions(g/km)                     Smog Rating                            -0.520437
Smog Rating                             Fuel Consumption (City (L/100 km)      -0.523928
Fuel Consumption(Comb (mpg))            Cylinders                              -0.693594
Engine Size(L)                          Fuel Consumption(Comb (mpg))           -0.704163
CO2 Rating                              Cylinders                              -0.762157
Engine Size(L)                          CO2 Rating                             -0.766333
Fuel Consumption(Hwy (L/100 km))        Fuel Consumption(Comb (mpg))           -0.877531
CO2 Rating                              Fuel Consumption(Hwy (L/100 km))       -0.894668
Fuel Consumption(Comb (mpg))            Fuel Consumption (City (L/100 km)      -0.909477
CO2 Emissions(g/km)                     Fuel Consumption(Comb (mpg))           -0.913019
Fuel Consumption(Comb (mpg))            Fuel Consumption(Comb (L/100 km))      -0.914305
Fuel Consumption (City (L/100 km)       CO2 Rating                             -0.920524
CO2 Rating                              Fuel Consumption(Comb (L/100 km))      -0.927705
                                        CO2 Emissions(g/km)                    -0.954593
dtype: float64
```

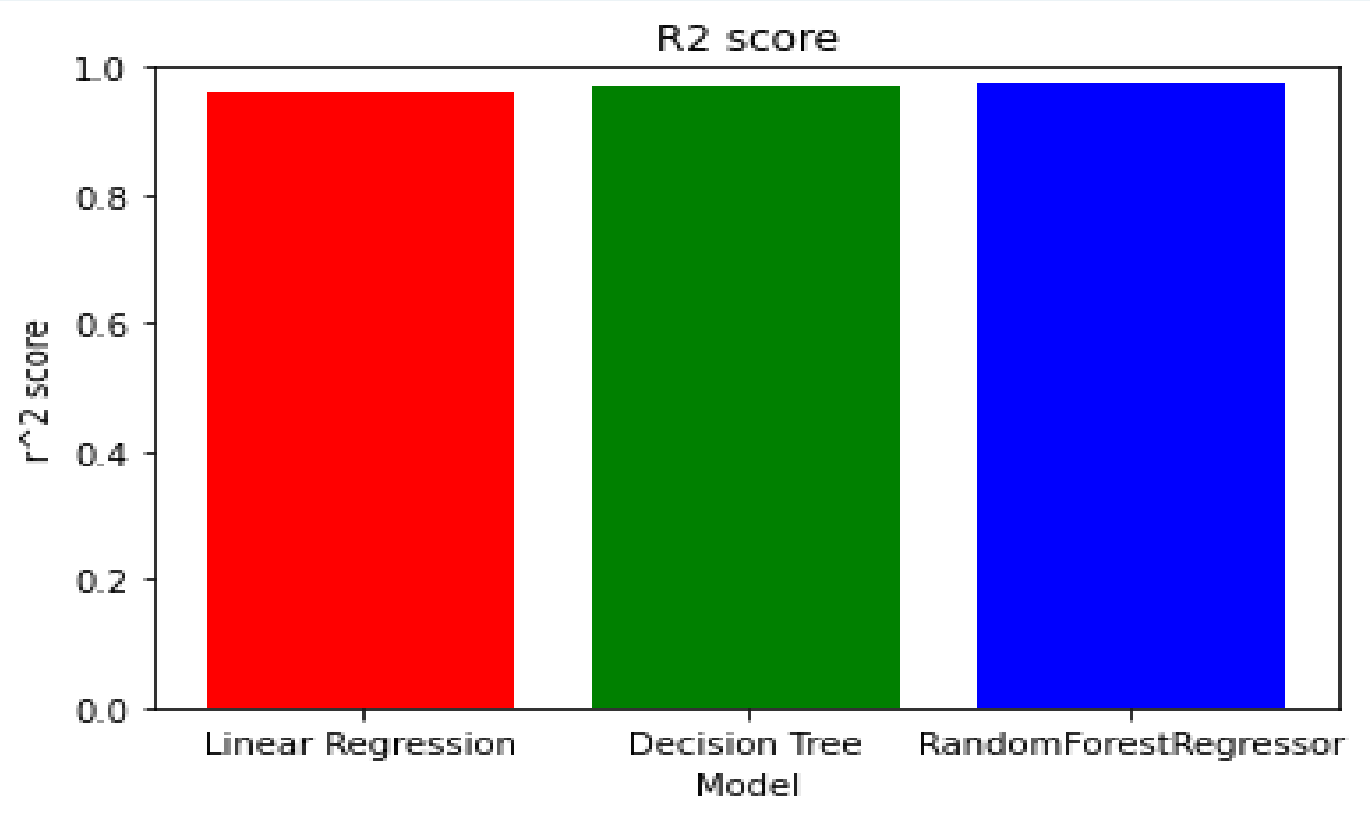

Engine Size(L) 1 0.92 0.83 0.75 0.82 -0.7 0.82 -0.77 -0.45
Cylinders 0.92 1 0.85 0.74 0.82 -0.69 0.83 -0.76 -0.5
Fuel Consumption (City (L/100 km) 0.83 0.85 1 0.92 0.99 -0.91 0.97 -0.92 -0.52
Fuel Consumption(Hwy (L/100 km)) 0.75 0.74 0.92 1 0.97 -0.88 0.93 -0.89 -0.4
Fuel Consumption(Comb (L/100 km)) 0.82 0.82 0.99 0.97 1 -0.91 0.97 -0.93 -0.49
Fuel Consumption(Comb (mpg)) -0.7 -0.69 -0.91 -0.88 -0.91 1 -0.91 0.95 0.47
CO2 Emissions(g/km) 0.82 0.83 0.97 0.93 0.97 -0.91 1 -0.95 -0.52
CO2 Rating -0.77 -0.76 -0.92 -0.89 -0.93 0.95 -0.95 1 0.5
Smog Rating -0.45 -0.5 -0.52 -0.4 -0.49 0.47 -0.52 0.5 1
Engine Size(L)
Cylinders
Fuel Consumption (City (L/100 km)
Fuel Consumption(Hwy (L/100 km))
Fuel Consumption(Comb (L/100 km))
Fuel Consumption(Comb (mpg))
CO2 Emissions(g/km)
CO2 Rating
Smog Rating
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75

Mechine Learning
Prediction for CO2 Emissions
LinearRegression

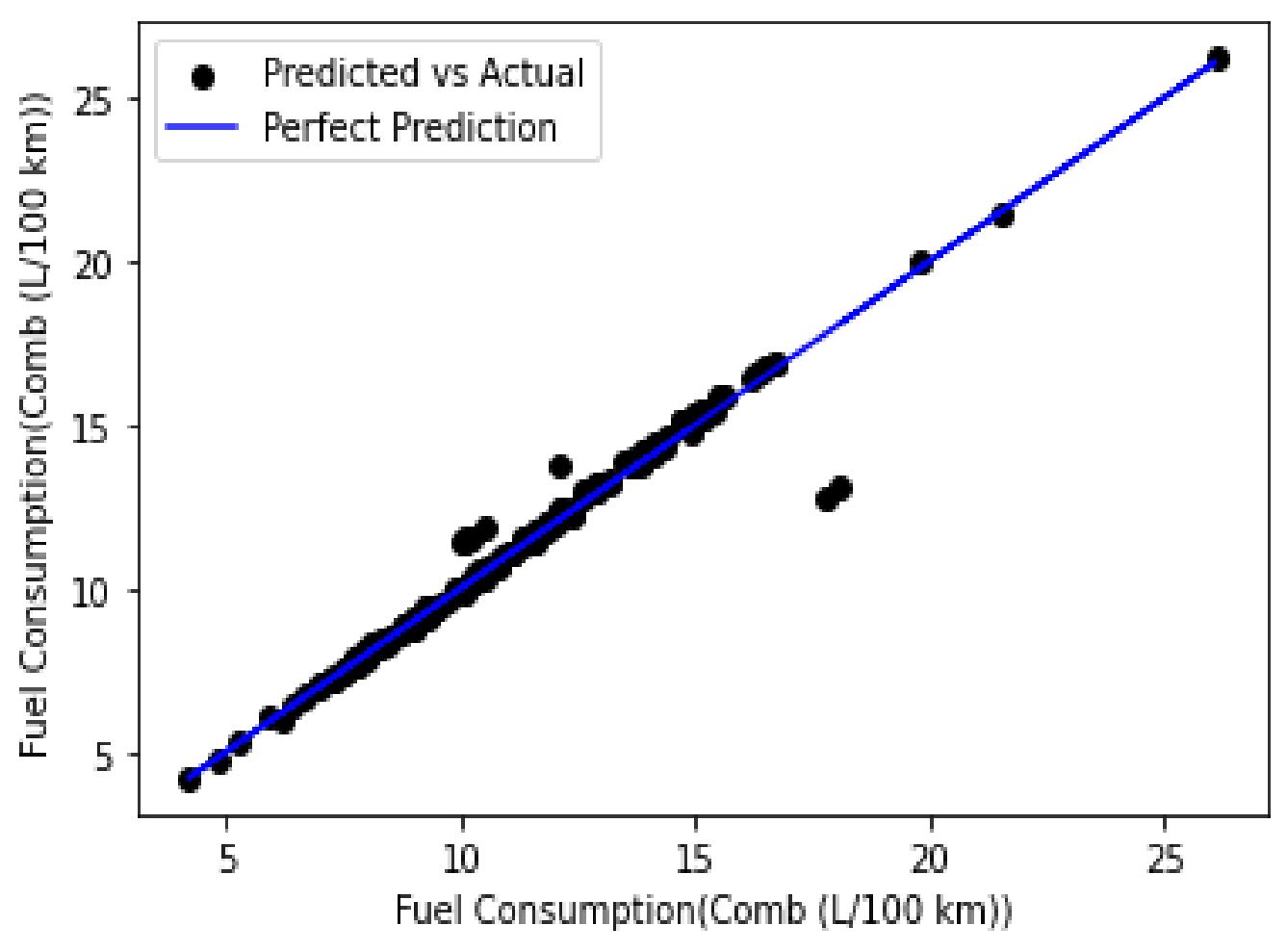


CO2

	CO2_Prediction	R2 Score
0	Linear Regression	0.96028
1	Decision Tree	0.96755
2	RandomForestRegressor	0.97386

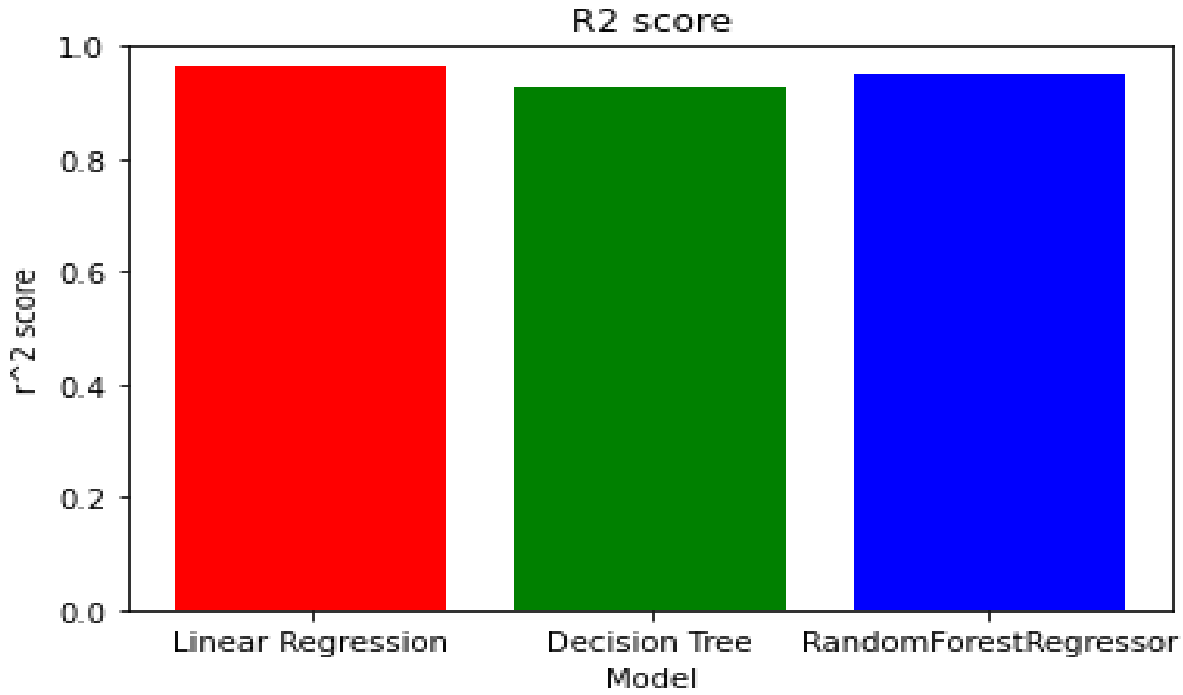


Prediction for Fuel Consumption LinearRegression



fuel

	FuelConsumption_Prediction	R2 Score
0	Linear Regression	0.96396
1	Decision Tree	0.92727
2	RandomForestRegressor	0.95008



Recommendations

A list of recommendations for customers who currently wish to buy new vehicles is as follows:

• Fuel-saver and environmental-friendly brands: Honda, Mitsubishi, Mazda, FIAT, Hyundai, MINI, Kia, and Volkswagen;

• Least smog-emitter brands: Volkswagen, Jaguar, MINI, Mazda, Toyota, Volvo, and Lexus. Conversely, customers who are environmental friendly ought to reconsider the following brand

• Brands with high smog emissions: Bugatti, Lamborghini, Maserati, Porsche, Dodge, Alfa Romeo, and Bentley. Recommendations for both vehicle producers and customers who strive to be green in their products are as follows:

•Engine models: IONIQ Blue, IONIQ, Prius, Corolla Hybrid, And Niro FE;

• Suggested Vehicle Classes: Station wagon (Small), Compact, Mid-size, and SUV (Small);

• For engine size and cylinder, the smaller, the better for fuel consumption and CO2 emissions;

• Suggested transmission type: AV1, AV, AM6, AV10, and AV6;

• About Fuel type, it is recommended to use fuel types D (Diesel) and X (Regular gasoline).

Conclusions

- an observational and predictive analysis has been performed using data from the Government of 2022 fuel consumption rating, to provide a comparative view of various brands and vehicle types in terms of fuel consumption and CO2 emissions before making applicable recommendations. . Finally, it should be noted that LinearRegression is promising for predicting in this field, with stable and high coverage of correct predicted values.

References

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