Co2 Emissions

November 15, 2022

In this report, a machine learning regression system is designed and implemented to compute the Co2 emissions of vehicles. The dataset that was used for this experiment can be downloaded from this site. FuelConsumption

The independent variables are

- MODELYEAR
- MAKE
- MODEL
- VEHICLE CLASS
- ENGINE SIZE
- CYLINDERS
- TRANSMISSION
- FUEL CONSUMPTION in CITY(L/100 km)
- FUEL CONSUMPTION in HWY (L/100 km)
- FUEL CONSUMPTION COMB (L/100 km)
- CO2 EMISSIONS (g/km)

The dependent variable is

- CO2 EMISSIONS (g/km)

Tools Tools To implement the proposed system, four main libraries need to be downloaded. These libraries are listed below. Libraries and frameworks

- Pandas
- Numpy
- Matplotlib
- scikit-learn

Import the main libraries and functions

[1]:
```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

take a look at the dataset

[2]:
```
df = pd.read_csv("FuelConsumption.csv")
df.head(3)
```

[2]:

	MODELYEAR	MAKE	MODEL	VEHICLECLASS	ENGINESIZE	CYLINDERS	\
0	2014	ACURA	ILX	COMPACT	2.0	4	
1	2014	ACURA	ILX	COMPACT	2.4	4	

```
2       2014  ACURA  ILX HYBRID      COMPACT         1.5          4

  TRANSMISSION FUELTYPE  FUELCONSUMPTION_CITY  FUELCONSUMPTION_HWY  \
0          AS5        Z                   9.9                  6.7
1           M6        Z                  11.2                  7.7
2          AV7        Z                   6.0                  5.8

   FUELCONSUMPTION_COMB  FUELCONSUMPTION_COMB_MPG  CO2EMISSIONS
0                   8.5                        33           196
1                   9.6                        29           221
2                   5.9                        48           136
```

Summarize the data

[3]:
```
df.describe().mean()
```

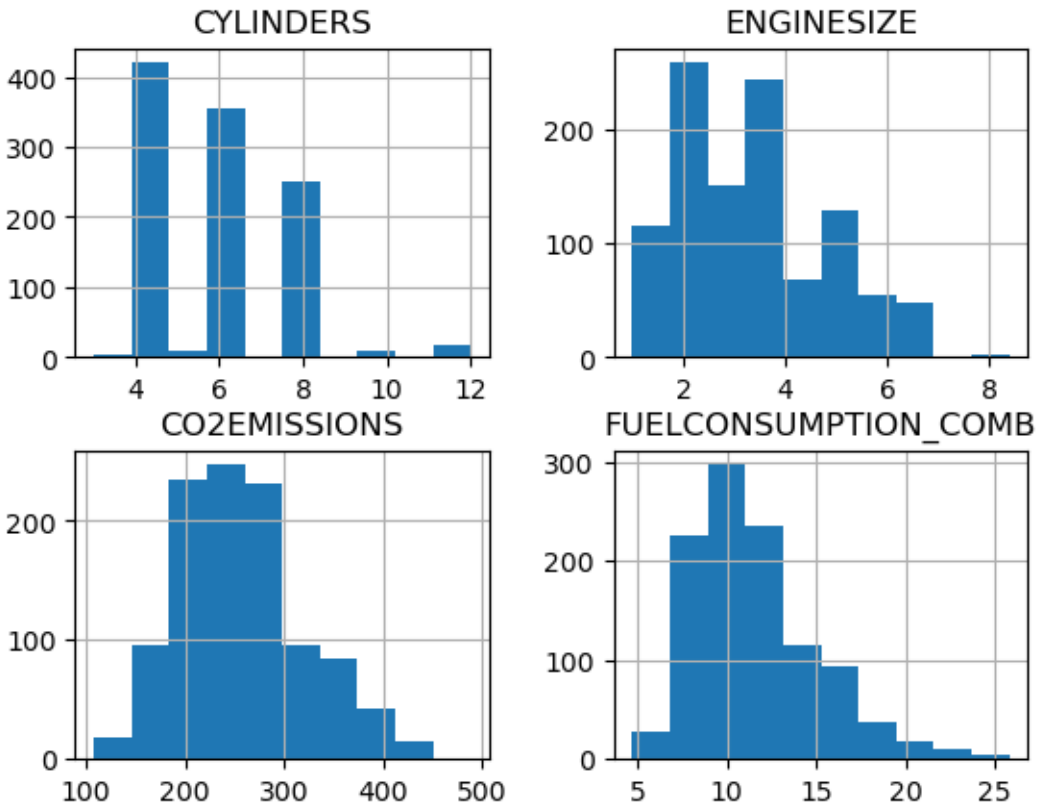
[3]:
```
MODELYEAR                   1643.875000
ENGINESIZE                   136.357774
CYLINDERS                    138.449025
FUELCONSUMPTION_CITY         144.699723
FUELCONSUMPTION_HWY          141.477389
FUELCONSUMPTION_COMB         143.227059
FUELCONSUMPTION_COMB_MPG     156.238766
CO2EMISSIONS                 341.825123
dtype: float64
```

Select some features

[4]:
```
cdf = df[['ENGINESIZE','CYLINDERS','FUELCONSUMPTION_COMB','CO2EMISSIONS']]
```

[5]:
```
viz = cdf[['CYLINDERS','ENGINESIZE','CO2EMISSIONS','FUELCONSUMPTION_COMB']]
viz.hist()
```

[5]:
```
array([[<AxesSubplot:title={'center':'CYLINDERS'}>,
        <AxesSubplot:title={'center':'ENGINESIZE'}>],
       [<AxesSubplot:title={'center':'CO2EMISSIONS'}>,
        <AxesSubplot:title={'center':'FUELCONSUMPTION_COMB'}>]],
      dtype=object)
```

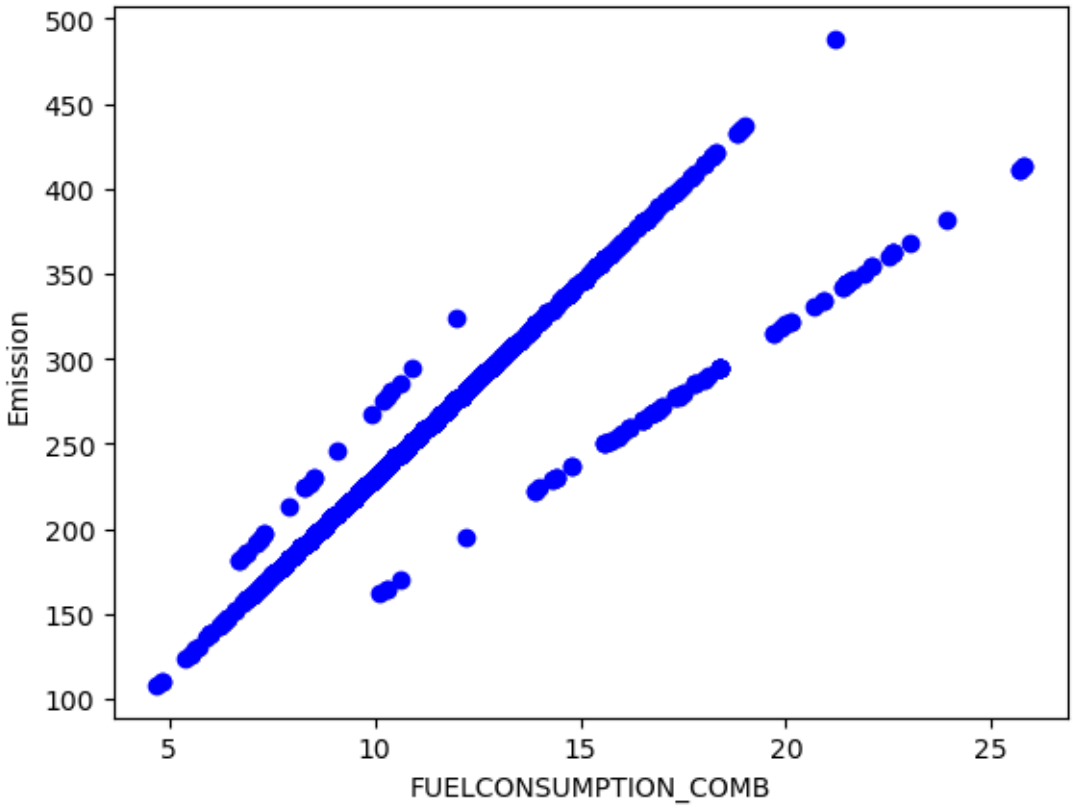


Plot each of these features against the Emission, to see how linear their relationship

1- FUELCONSUMPTION_COMB with CO2EMISSIONS

[6]:
```
plt.scatter(cdf.FUELCONSUMPTION_COMB, cdf.CO2EMISSIONS,  color='blue')
plt.xlabel("FUELCONSUMPTION_COMB")
plt.ylabel("Emission")
```

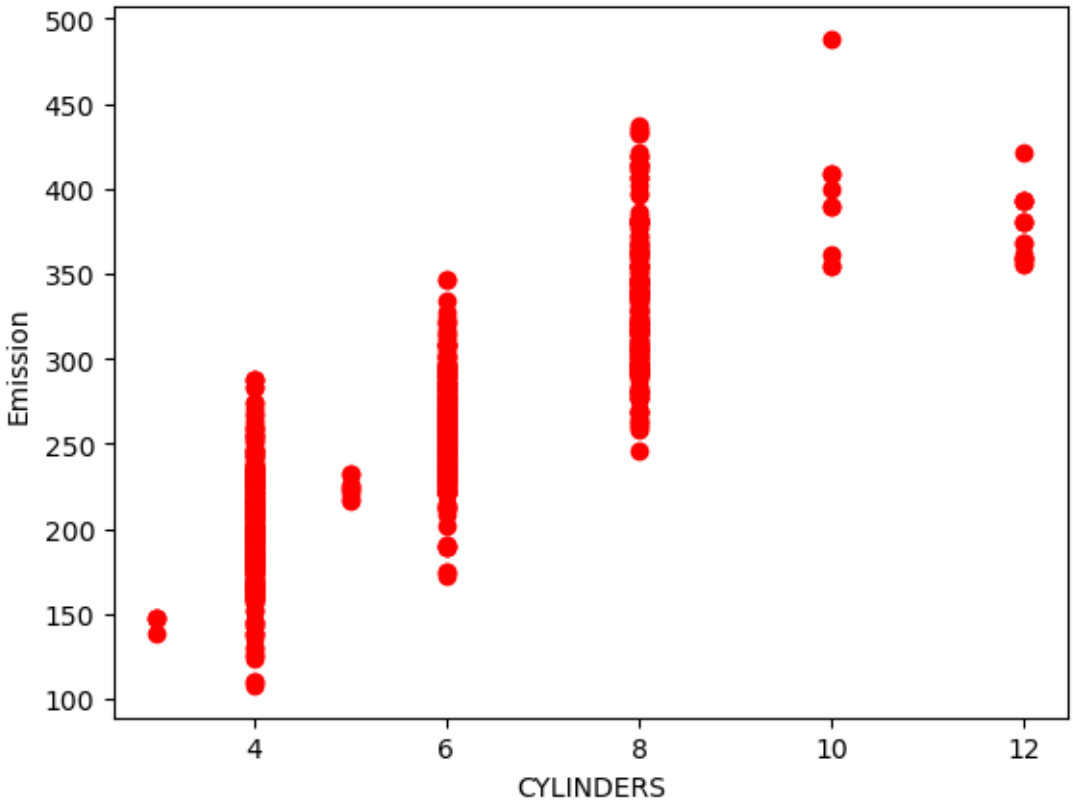
[6]: Text(0, 0.5, 'Emission')



2- CYLINDERS with CO2EMISSIONS

[7]:
```
plt.scatter(cdf.CYLINDERS, cdf.CO2EMISSIONS,  color='red')
plt.xlabel("CYLINDERS")
plt.ylabel("Emission")
```

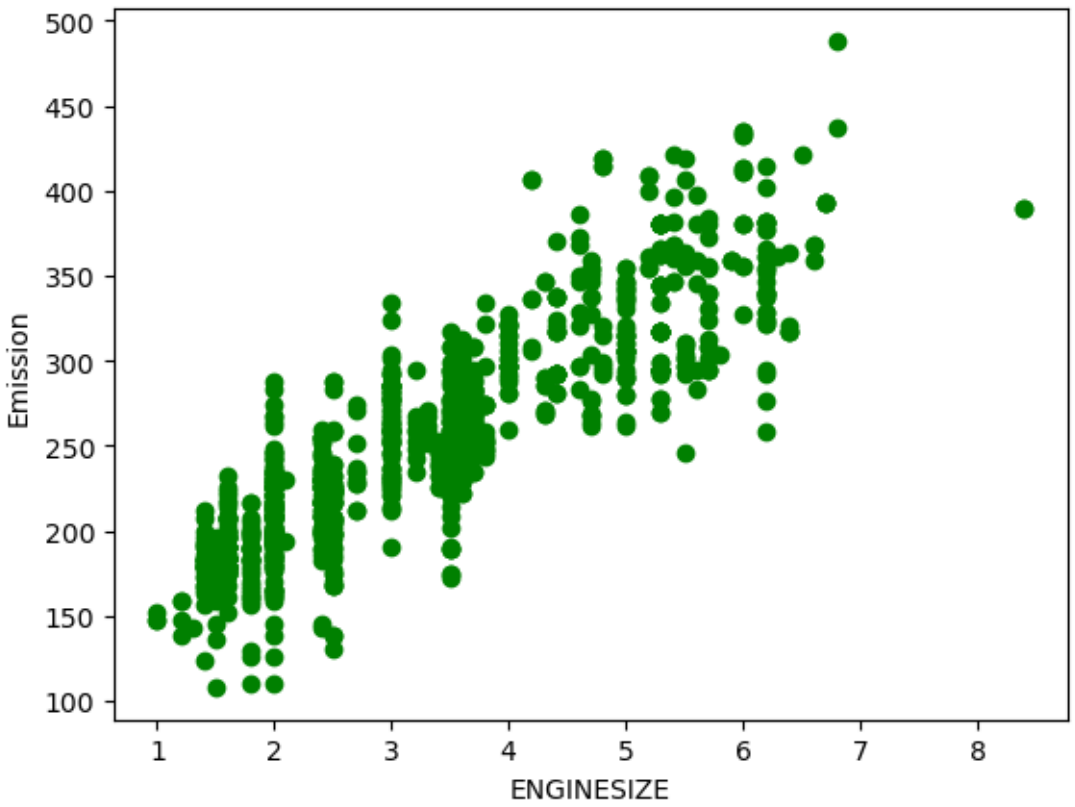
[7]:
```
Text(0, 0.5, 'Emission')
```



3- ENGINESIZE with CO2EMISSIONS

[8]:
```
plt.scatter(cdf.ENGINESIZE, cdf.CO2EMISSIONS,  color='green')
plt.xlabel("ENGINESIZE")
plt.ylabel("Emission")
```

[8]:
```
Text(0, 0.5, 'Emission')
```



Creating a train and test dataset by randomly selecting 80% of the data for training and 20% for testing.

[9]:
```
msk = np.random.rand(len(df)) < 0.8
train = cdf[msk]
test = cdf[~msk]
```

[10]:
```
from sklearn import linear_model
regr = linear_model.LinearRegression()
train_x = np.asanyarray(train[['ENGINESIZE']])
train_y = np.asanyarray(train[['CO2EMISSIONS']])
regr.fit(train_x, train_y)
# The coefficients
print ('Coefficients: ', regr.coef_)
print ('Intercept: ',regr.intercept_)
```

```
Coefficients:  [[38.61324843]]
Intercept:  [126.86355405]
```

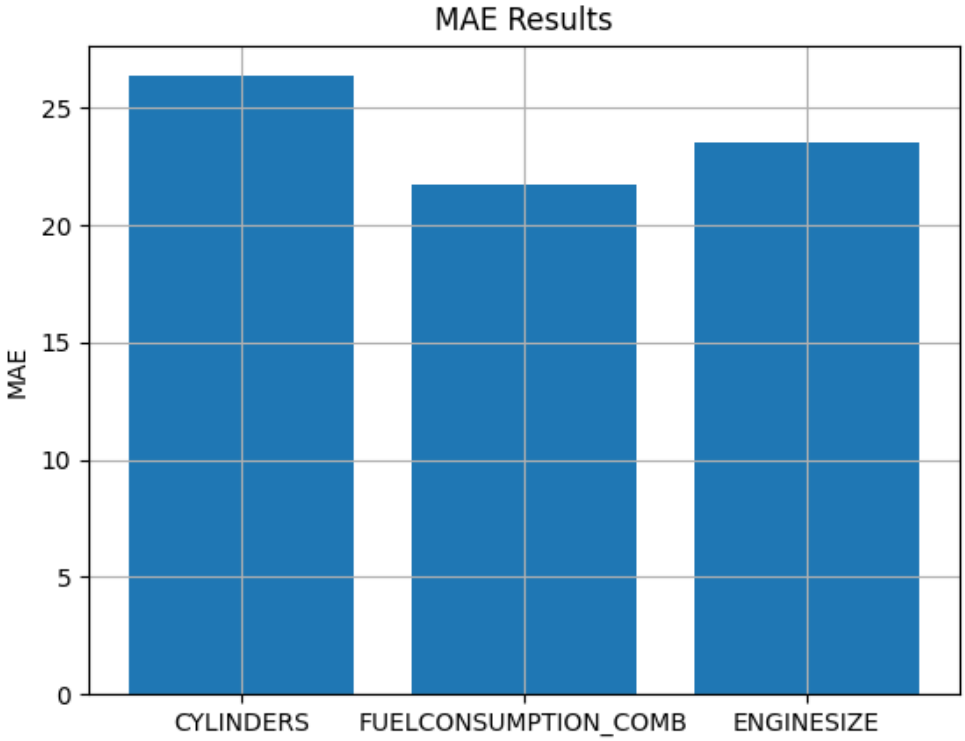
Evaluate the system

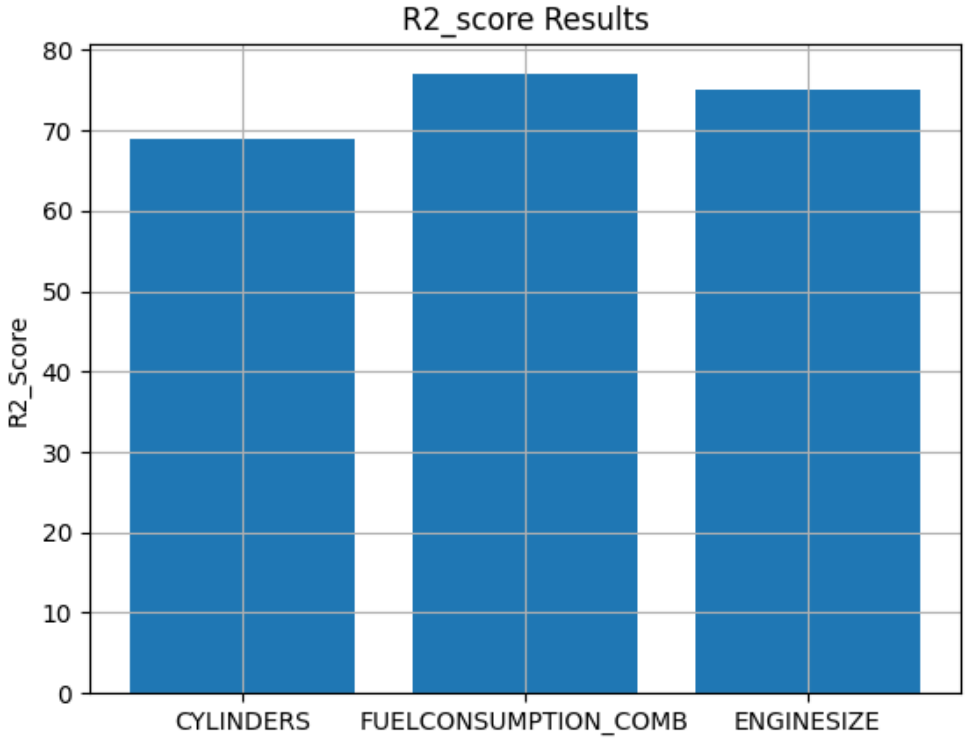
[11]:
```
from sklearn.metrics import r2_score
test_x = np.asanyarray(test[['ENGINESIZE']])
test_y = np.asanyarray(test[['CO2EMISSIONS']])
test_y_ = regr.predict(test_x)
```

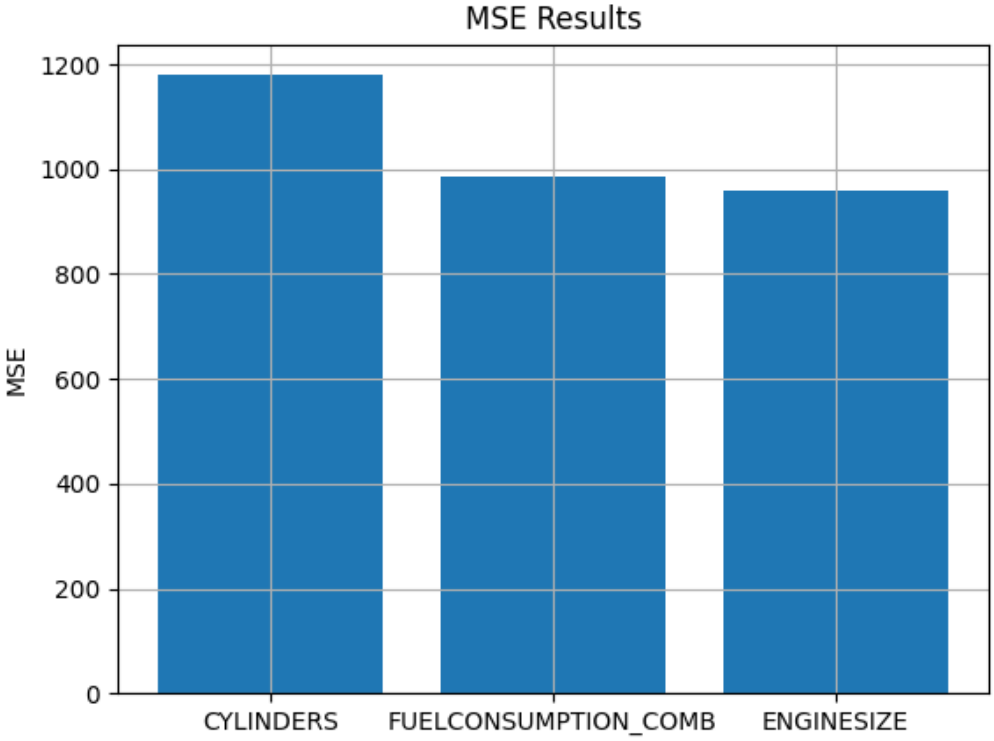
[12]:
```
print("Mean absolute error: %.2f" % np.mean(np.absolute(test_y_ - test_y)))
print("Residual sum of squares (MSE): %.2f" % np.mean((test_y_ - test_y) ** 2))
print("R2-score: %.2f" % r2_score(test_y , test_y_) )
```

```
Mean absolute error: 24.30
Residual sum of squares (MSE): 1017.53
R2-score: 0.77
```

With the same process, they compute the results using FUELCONSUMPTION_COMB and CYLINDERS as independent variables. The figures below show the main difference.




R2_score Results
R2_Score
80
70
60
50
40
30
20
10
0
CYLINDERS
FUELCONSUMPTION_COMB
ENGINESIZE


MSE Results
MSE
1200
1000
800
600
400
200
0
CYLINDERS
FUELCONSUMPTION_COMB
ENGINESIZE

Conclusion In the experiment, the CO2 emissions system is proposed based on the linear regression system. The proposed system is implemented and designed using the Python programming language. Three independent variables are used (engine size, number of cylinders, and fuel consumption). Three evaluation metrics are used to compute the results (MES, MAE, and R2_score). The findings show that using fuel consumption as an independent variable is more efficient than other ones since it achieves higher performance. The R2-score for the number of cylinders used was 69%, and the engine size was 76%, while the R2-score for fuel consumption was 77%.