CO2 Emissions Prediction

Group 4

Anjana Nallanagula - AP19110010340

Lasya Nagamlla - AP19110010365

Chandana Kovelamudi - AP19110010369

Hema Sai Kota - AP19110010454

Bhavana Tondupalli - AP19110010482

In [ ]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
df = pd.read_csv("/content/CO2 Emissions_Canada.csv")
df.head()
```

Out[ ]:

	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)	F Consumpt Comb (m
0	ACURA	ILX	COMPACT	2.0	4	AS5	Z	9.9	6.7	8.5	3
1	ACURA	ILX	COMPACT	2.4	4	M6	Z	11.2	7.7	9.6	2
2	ACURA	ILX HYBRID	COMPACT	1.5	4	AV7	Z	6.0	5.8	5.9	4
3	ACURA	MDX 4WD	SUV - SMALL	3.5	6	AS6	Z	12.7	9.1	11.1	2
4	ACURA	RDX AWD	SUV - SMALL	3.5	6	AS6	Z	12.1	8.7	10.6	2

Data Description

In [ ]:

```
df.describe()
```

Out[ ]:

	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)
count	7385.000000	7385.000000	7270.000000	7302.000000	7284.000000	7278.000000	7145.000000
mean	3.160068	5.615030	12.551926	9.040386	10.968479	27.502748	250.555633
std	1.354170	1.828307	3.508690	2.224429	2.889250	7.230604	58.637658
min	0.900000	3.000000	1.000000	4.000000	4.100000	11.000000	96.000000
25%	2.000000	4.000000	10.100000	7.500000	8.900000	22.000000	208.000000
50%	3.000000	6.000000	12.100000	8.700000	10.600000	27.000000	246.000000
75%	3.700000	6.000000	14.600000	10.200000	12.600000	32.000000	288.000000
max	8.400000	16.000000	30.600000	20.600000	26.100000	69.000000	522.000000

Data Columns Information

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7385 entries, 0 to 7384
Data columns (total 12 columns):
 #   Column                            Non-Null Count  Dtype  
---  ------                            --------------  -----  
 0   Make                              7385 non-null   object 
 1   Model                             7385 non-null   object 
 2   Vehicle Class                     7385 non-null   object 
 3   Engine Size(L)                    7385 non-null   float64
 4   Cylinders                         7385 non-null   int64  
 5   Transmission                      7385 non-null   object 
 6   Fuel Type                         7379 non-null   object 
 7   Fuel Consumption City (L/100 km)  7270 non-null   float64
 8   Fuel Consumption Hwy (L/100 km)   7302 non-null   float64
 9   Fuel Consumption Comb (L/100 km)  7284 non-null   float64
 10  Fuel Consumption Comb (mpg)       7278 non-null   float64
 11  CO2 Emissions(g/km)               7145 non-null   float64
dtypes: float64(6), int64(1), object(5)
memory usage: 692.5+ KB
```

Identifying Missing Values

In [ ]:

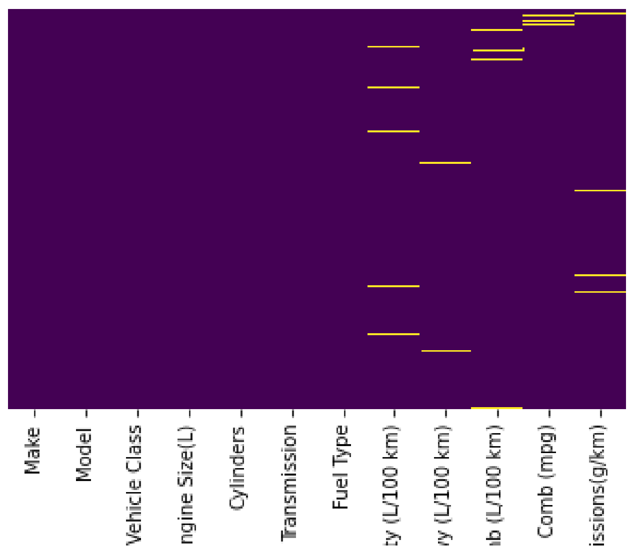
```
df.isnull().sum()
```

Out[ ]:

```
Make                                  0
Model                                 0
Vehicle Class                         0
Engine Size(L)                        0
Cylinders                             0
Transmission                          0
Fuel Type                             6
Fuel Consumption City (L/100 km)    115
Fuel Consumption Hwy (L/100 km)      83
Fuel Consumption Comb (L/100 km)    101
Fuel Consumption Comb (mpg)         107
CO2 Emissions(g/km)                 240
dtype: int64
```

In [ ]:

```
sns.heatmap(df.isnull(),yticklabels=False,cbar=False,cmap='viridis')
plt.show()
```



In [ ]:

```
df['Fuel Type'].fillna(df['Fuel Type'].mode().iloc[0], inplace = True)
print(f"No. of Null Values: {df['Fuel Type'].isnull().sum()}")
print(f"Fuel Type is filled with the repeated value {df['Fuel Type'].mode().iloc[0]}")
```

```
No. of Null Values: 0
Fuel Type is filled with the repeated value X
```

In [ ]:

```
x = df['Fuel Consumption City (L/100 km)'].mean()
print(f"Mean: {round(x, 2)}")
df['Fuel Consumption City (L/100 km)'].fillna(round(x,2),inplace=True)
print(f"No. of Null Values: {df['Fuel Consumption City (L/100 km)'].isnull().sum()}")

if (round(x,2) in df['Fuel Consumption City (L/100 km)'].unique()):
  print(f"Fuel Consumption City (L/100 km) is filled with mean {round(x, 2)}")
```

```
Mean: 12.55
No. of Null Values: 0
Fuel Consumption City (L/100 km) is filled with mean 12.55
```

In [ ]:

```
df['Fuel Consumption Hwy (L/100 km)'].bfill(inplace=True)

print(f"No. of Null Values: {df['Fuel Consumption Hwy (L/100 km)'].isnull().sum()}")
```

```
No. of Null Values: 0
```

In [ ]:

```
df['Fuel Consumption Comb (L/100 km)'].ffill(inplace = True)

print(f"No. of Null Values: {df['Fuel Consumption Comb (L/100 km)'].isnull().sum()}")
```

```
No. of Null Values: 0
```

In [ ]:

```
df['Fuel Consumption Comb (mpg)'].interpolate(inplace = True)

print(f"No. of Null Values: {df['Fuel Consumption Comb (mpg)'].isnull().sum()}")
```

```
No. of Null Values: 0
```

In [ ]:

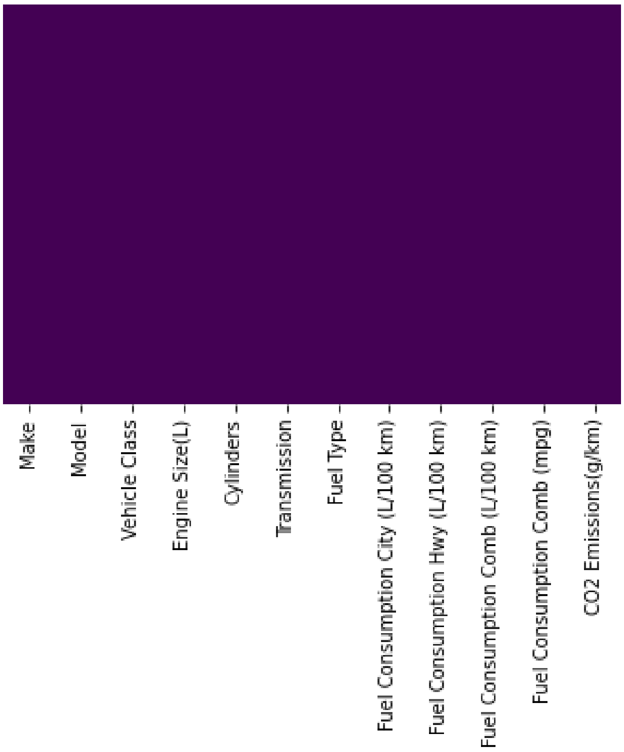
```
x = df['CO2 Emissions(g/km)'].median()
print(f"Median: {round(x, 2)}")
df['CO2 Emissions(g/km)'].fillna(round(x,2),inplace=True)
print(f"No. of Null Values: {df['CO2 Emissions(g/km)'].isnull().sum()}")

if (x in df['CO2 Emissions(g/km)'].unique()):
  print(f"CO2 Emissions(g/km) is filled with meadian {x}")
```

```
Median: 246.0
No. of Null Values: 0
CO2 Emissions(g/km) is filled with meadian 246.0
```

In [ ]:

```
sns.heatmap(df.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

```
plt.show()
```

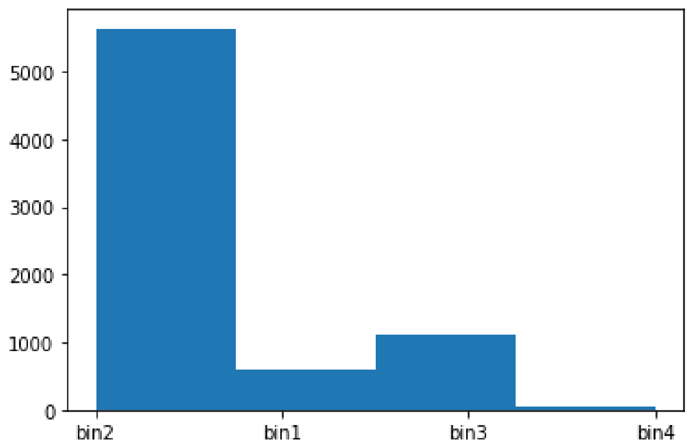


Identifying Noisy Data

In [ ]:

```
#binning by distance
min_value = df['Fuel Consumption City (L/100 km)'].min()
max_value = df['Fuel Consumption City (L/100 km)'].max()
print(f'minimum value: {min_value}')
print(f'maximum value: {max_value}')
bins = np.linspace(min_value,max_value,5)
print(f'bin edges: {bins}')
labels = ['bin1', 'bin2', 'bin3','bin4']
df['bins'] = pd.cut(df['Fuel Consumption City (L/100 km)'], bins=bins, labels=labels, in
clude_lowest=True)
plt.hist(df['bins'], bins=4)
plt.show()
```

```
minimum value: 1.0
maximum value: 30.6
bin edges: [ 1.   8.4 15.8 23.2 30.6]
```



In [ ]:

```
#binning by mean

noisy=df['Fuel Consumption Hwy (L/100 km)']
min_value = df['Fuel Consumption Hwy (L/100 km)'].min()
```

```
max_value = df['Fuel Consumption Hwy (L/100 km)'].max()
print(f'minimum value: {min_value}')
print(f'maximum value: {max_value}')
np.sort(noisy) #sorting the array
```

```
minimum value: 4.0
maximum value: 20.6
```

Out[ ]:

```
array([ 4. ,  4. ,  4. , ..., 20.5, 20.6, 20.6])
```

In [ ]:

```
bin1=np.zeros((1477,5))
for i in range(0,7385,5):
 y=int(i/5)
 mean=(noisy[i]+noisy[i+1]+noisy[i+2]+noisy[i+3]+noisy[i+4])/5
 for j in range(5):
   bin1[y,j]=mean
print(bin1)
```

```
[[7.6  7.6  7.6  7.6  7.6 ]
 [8.46 8.46 8.46 8.46 8.46]
 [9.44 9.44 9.44 9.44 9.44]
 ...
 [7.64 7.64 7.64 7.64 7.64]
 [7.5  7.5  7.5  7.5  7.5 ]
 [8.32 8.32 8.32 8.32 8.32]]
```

In [ ]:

```
noisy1=df['Fuel Consumption Comb (L/100 km)']
min_value = df['Fuel Consumption Comb (L/100 km)'].min()
max_value = df['Fuel Consumption Comb (L/100 km)'].max()
print(f'minimum value: {min_value}')
print(f'maximum value: {max_value}')
np.sort(noisy1) #sorting the array
```

```
minimum value: 4.1
maximum value: 26.1
```

Out[ ]:

```
array([ 4.1,  4.1,  4.1, ..., 25.9, 26.1, 26.1])
```

In [ ]:

```
#binning by median
bin2=np.zeros((1477,5))
for i in range(0,7385,5):
 y=int(i/5)
 for j in range(5):
  bin2[y,j]=noisy1[i+1]
print(bin2)
```

```
[[ 9.6  9.6  9.6  9.6  9.6]
 [10.1 10.1 10.1 10.1 10.1]
 [ 9.8  9.8  9.8  9.8  9.8]
 ...
 [ 9.4  9.4  9.4  9.4  9.4]
 [ 8.9  8.9  8.9  8.9  8.9]
 [ 9.9  9.9  9.9  9.9  9.9]]
```

In [ ]:

```
#binning by boundary
noisy3=df['CO2 Emissions(g/km)']
np.sort(noisy3)
bin3=np.zeros((1477,5))
for i in range(0,7385,5):
 x=int(i/5)
 for j in range(5):
```

```
    if(noisy3[i+j]-noisy3[i])<(noisy3[i+4]-noisy3[i+j]):
     bin3[x,j]=noisy3[i]
    else:
     bin3[x,j]=noisy3[i+4]
print(bin3)
```

```
[[196. 244. 196. 244. 244.]
 [212. 212. 212. 212. 230.]
 [225. 225. 225. 359. 359.]
 ...
 [205. 246. 246. 205. 246.]
 [210. 223. 210. 210. 223.]
 [219. 219. 248. 219. 248.]]
```

Data Transformation

In [ ]:

```
df['Engine Size(L)'] = (df['Engine Size(L)'] - df['Engine Size(L)'].min()) / (df['Engine Size(L)'].max() - df['Engine Size(L)'].min())
df['Cylinders'] = (df['Cylinders'] - df['Cylinders'].min()) / (df['Cylinders'].max() - df['Cylinders'].min())
df['Fuel Consumption Comb (mpg)'] = (df['Fuel Consumption Comb (mpg)'] - df['Fuel Consumption Comb (mpg)'].min()) / (df['Fuel Consumption Comb (mpg)'].max() - df['Fuel Consumption Comb (mpg)'].min())
```

In [ ]:

```
df['Fuel Consumption City (L/100 km)'] = (df['Fuel Consumption City (L/100 km)'] - df['Fuel Consumption City (L/100 km)'].mean()) / df['Fuel Consumption City (L/100 km)'].std()
df['Fuel Consumption Hwy (L/100 km)'] = (df['Fuel Consumption Hwy (L/100 km)'] - df['Fuel Consumption Hwy (L/100 km)'].mean()) / df['Fuel Consumption Hwy (L/100 km)'].std()
df['Fuel Consumption Comb (L/100 km)'] = (df['Fuel Consumption Comb (L/100 km)'] - df['Fuel Consumption Comb (L/100 km)'].mean()) / df['Fuel Consumption Comb (L/100 km)'].std()
```

In [ ]:

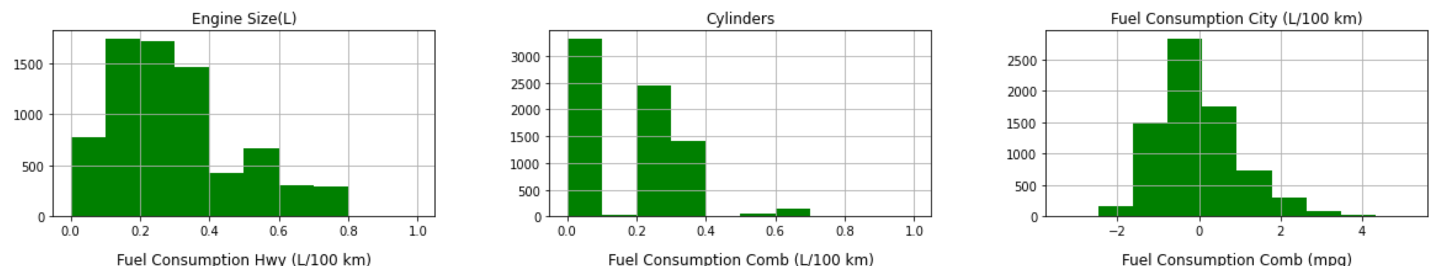
```
import math

max1 = 0
for i in df['CO2 Emissions(g/km)']:
  max1 = max(max1, abs(i))
j = len(str(math.ceil(max1)))

df['CO2 Emissions(g/km)'] = df['CO2 Emissions(g/km)'] / 10 ** j
print(df['CO2 Emissions(g/km)'][:5])
```

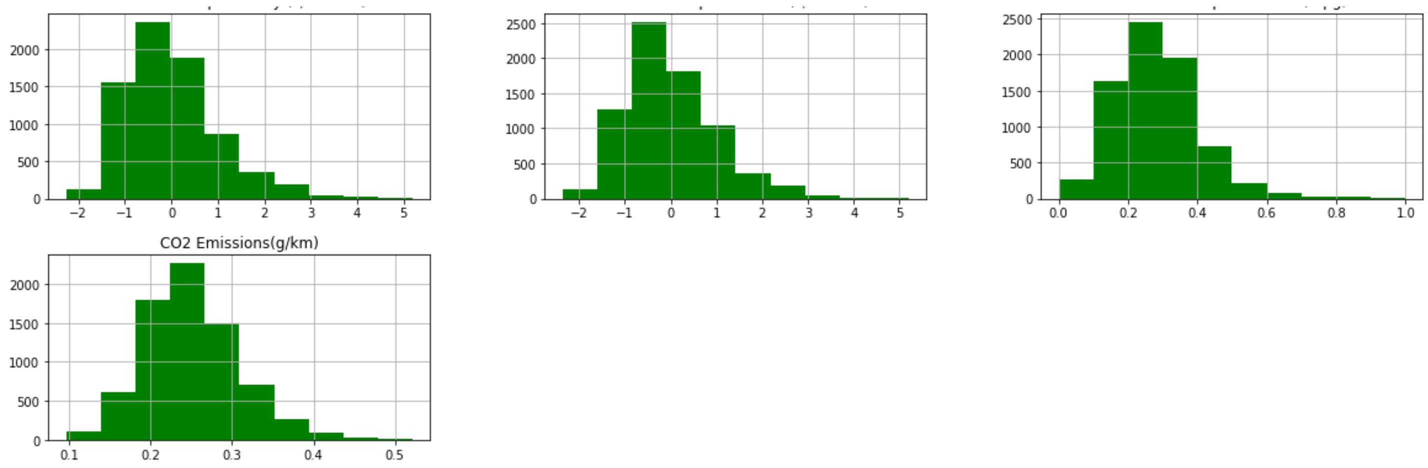
```
0    0.196
1    0.221
2    0.136
3    0.255
4    0.244
Name: CO2 Emissions(g/km), dtype: float64
```

Histograms

In [ ]:

```
ls = df.select_dtypes(include = ['int64','float'])
ls.hist(figsize = (20,10), color='green')
plt.show()
```





Data Selection Using Principal Component Analysis

In [ ]:

```
from sklearn.decomposition import PCA
pca = PCA(n_components=2)
pct=pca.fit_transform(df.iloc[:,7:-2])
principal_df = pd.DataFrame (pct,columns=['pc1', 'pc2'])
finaldf=pd.concat([principal_df,df[['CO2 Emissions(g/km)']]],axis=1)
```

In [ ]:

```
finaldf.head(10)
```

Out[ ]:

	pc1	pc2	CO2 Emissions(g/km)
0	-1.543277	-0.213312	0.196
1	-0.845879	-0.155735	0.221
2	-2.957296	0.304350	0.136
3	0.067801	-0.012778	0.255
4	-0.236847	-0.018682	0.244
5	-0.649030	-0.300081	0.230
6	-0.416859	-0.290914	0.232
7	0.187422	0.103683	0.255
8	0.287611	-0.009582	0.267
9	-0.757059	-0.463054	0.212

In [ ]:

```
pca=PCA(n_components=2)
principalcomponents=pca.fit_transform(df.iloc[:,7:-2])

principal_Df1=pd.DataFrame(data=principalcomponents
                           ,columns=['principal component 1', 'principal component 2'])

final_Df1=pd.concat([principal_Df1, df[['CO2 Emissions(g/km)']]], axis=1)
final_Df1.tail(5)
```

Out[ ]:

	principal component 1	principal component 2	CO2 Emissions(g/km)
7380	-0.664273	-0.402263	0.219
7381	-0.631090	0.037871	0.232
7382	-0.388766	0.031814	0.240

	principal component 1	principal component 2	CO2 Emissions(g/km)
7383	-0.631090	0.037871	0.232
7384	-0.144831	-0.104880	0.248

Correlation Matrix

In [ ]:

```
final_Df1.corr()
```

Out[ ]:

	principal component 1	principal component 2	CO2 Emissions(g/km)
principal component 1	1.000000e+00	1.748411e-17	0.901892
principal component 2	1.748411e-17	1.000000e+00	-0.076511
CO2 Emissions(g/km)	9.018925e-01	-7.651090e-02	1.000000

Linear Regression

Independent Variable : Principle Component 1

Dependent Variable : CO2 Emissions(g/km)

In [ ]:

```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn import metrics

X = final_Df1.drop(['CO2 Emissions(g/km)', 'principal component 2'],axis=1).values
y = final_Df1['CO2 Emissions(g/km)'].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=0)
```

In [ ]:

```
model = LinearRegression()
model.fit(X_train, y_train)

print(f"Intercept : {model.intercept_}")
print(f"Coefficient : {model.coef_}")
```

```
Intercept : 0.2505023098670213
Coefficient : [0.03035731]
```

In [ ]:

```
y_pred = model.predict(X_test)
```

In [ ]:

```
df1 = pd.DataFrame({'Actual': y_test, 'Predicted': y_pred})
df1.tail()
```

Out[ ]:

	Actual	Predicted
2211	0.255	0.224304
2212	0.290	0.276709
2213	0.242	0.239528
2214	0.190	0.201239
2215	0.214	0.217529

In [ ]:

In [ ]:

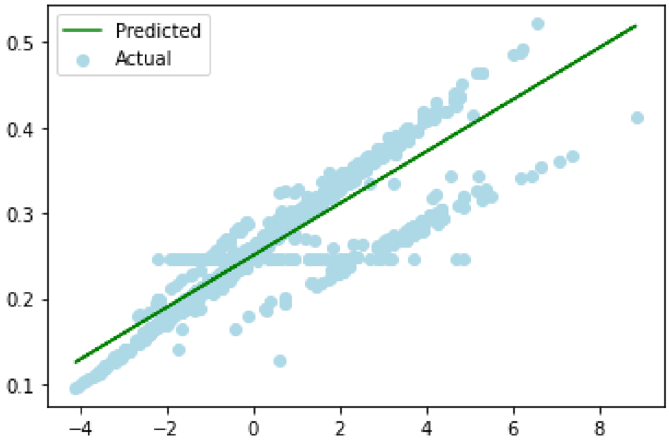
```
d = float(input("Enter the value of the independent variable : "))
m = model.predict([[d]])
print(f"The predicted value is : {m}")
```

```
Enter the value of the independent variable : 0.214
The predicted value is : [0.25699877]
```

Linear Regression Graph

In [ ]:

```
plt.scatter(X_test, y_test, color = "lightblue", label="Actual")
plt.plot(X_test, y_pred, color = "green", label="Predicted")
plt.legend()
plt.show()
```



Accuracy and Error Values

In [ ]:

```
print('Mean Absolute Error:', round(metrics.mean_absolute_error(y_test, y_pred), 2))
print('Mean Squared Error:', round(metrics.mean_squared_error(y_test, y_pred), 2))
print('Root Mean Squared Error:', round(np.sqrt(metrics.mean_squared_error(y_test, y_pred
)), 2))
print('R-squared Error:', round(metrics.r2_score(y_test, y_pred), 2))
```

```
Mean Absolute Error: 0.02
Mean Squared Error: 0.0
Root Mean Squared Error: 0.02
R-squared Error: 0.81
```

In [ ]: