Vehicle Price Prediction - Internship Project

The goal of this project is to build a regression model to accurately predict the price of used vehicles based on their features like manufacturer, year, body, etc. reading.

Dependencies

In [ ]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, r2_score, mean_absolute_error
import seaborn as sns
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import RandomizedSearchCV
from sklearn.preprocessing import LabelEncoder
from scipy.stats import uniform
import re
```

Data Overview

- Importing csv

In [247...
```
data = pd.read_csv("dataset.csv")
```

In [248...
```
# Set the option to display all columns
pd.set_option('display.max_columns', None)
```

In [249...
```
data.head()
```

Out[249…

	name	description	make	model	year	price	engine	cylinders	fuel	mileage	tr
0	2024 Jeep Wagoneer Series II	\n \n Heated Leather Seats, Nav Sy...	Jeep	Wagoneer	2024	74600.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	10.0	
1	2024 Jeep Grand Cherokee Laredo	Al West is committed to offering every custome...	Jeep	Grand Cherokee	2024	50170.0	OHV	6.0	Gasoline	1.0	
2	2024 GMC Yukon XL Denali	NaN	GMC	Yukon XL	2024	96410.0	6.2L V-8 gasoline direct injection, variable v...	8.0	Gasoline	0.0	
3	2023 Dodge Durango Pursuit	White Knuckle Clearcoat 2023 Dodge Durango Pur...	Dodge	Durango	2023	46835.0	16V MPFI OHV	8.0	Gasoline	32.0	
4	2024 RAM 3500 Laramie	\n \n 2024 Ram 3500 Laramie Billet...	RAM	3500	2024	81663.0	24V DDI OHV Turbo Diesel	6.0	Diesel	10.0	

- Shape

In [250…

```
shape = data.shape
print(f"No of rows {shape[0]}")
print(f"No of cols {shape[1]}")
```

```
No of rows 1002
No of cols 17
```

- Info

In [251…

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1002 entries, 0 to 1001
Data columns (total 17 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   name            1002 non-null   object 
 1   description     946 non-null    object 
 2   make            1002 non-null   object 
 3   model           1002 non-null   object 
 4   year            1002 non-null   int64  
 5   price           979 non-null    float64
 6   engine          1000 non-null   object 
 7   cylinders       897 non-null    float64
 8   fuel            995 non-null    object 
 9   mileage         968 non-null    float64
 10  transmission    1000 non-null   object 
 11  trim            1001 non-null   object 
 12  body            999 non-null    object 
 13  doors           995 non-null    float64
 14  exterior_color  997 non-null    object 
 15  interior_color  964 non-null    object 
 16  drivetrain      1002 non-null   object 
dtypes: float64(4), int64(1), object(12)
memory usage: 133.2+ KB
```

In [252…

```
data.describe()
```

Out[252…

	year	price	cylinders	mileage	doors
count	1002.000000	979.000000	897.000000	968.000000	995.000000
mean	2023.916168	50202.985700	4.975474	69.033058	3.943719
std	0.298109	18700.392062	1.392526	507.435745	0.274409
min	2023.000000	0.000000	0.000000	0.000000	2.000000
25%	2024.000000	36600.000000	4.000000	4.000000	4.000000
50%	2024.000000	47165.000000	4.000000	8.000000	4.000000
75%	2024.000000	58919.500000	6.000000	13.000000	4.000000
max	2025.000000	195895.000000	8.000000	9711.000000	5.000000

- Columns name

In [253…

```
list(data.columns)
```

Out[253…
```
['name',
 'description',
 'make',
 'model',
 'year',
 'price',
 'engine',
 'cylinders',
 'fuel',
 'mileage',
 'transmission',
 'trim',
 'body',
 'doors',
 'exterior_color',
 'interior_color',
 'drivetrain']
```

- How many nan values are their in each column

In [254…
```
data.isna().sum()
```

Out[254…
```
name                0
description        56
make                0
model               0
year                0
price              23
engine              2
cylinders         105
fuel                7
mileage            34
transmission        2
trim                1
body                3
doors               7
exterior_color      5
interior_color     38
drivetrain          0
dtype: int64
```

- Every Category in each feature

In [255…
```
print("Drive Train: ", list(data['drivetrain'].unique()))
print("Makers Names: ", list(data['make'].unique()))
print("Cylinders: ", list(data['cylinders'].unique()))
print("Fuel Types: ", list(data['fuel'].unique()))
print("cars Body Type: ", list(data['body'].unique()))
print("No. of Doors: ", list(data['doors'].unique()))
```

```
Drive Train:  ['Four-wheel Drive', 'All-wheel Drive', 'Rear-wheel Drive', 'Front-wheel Drive']
Makers Names:  ['Jeep', 'GMC', 'Dodge', 'RAM', 'Nissan', 'Ford', 'Hyundai', 'Chevrolet', 'Volk
swagen', 'Chrysler', 'Kia', 'Mazda', 'Acura', 'Subaru', 'Audi', 'BMW', 'Toyota', 'Buick', 'Mer
cedes-Benz', 'Honda', 'Lincoln', 'Cadillac', 'INFINITI', 'Lexus', 'Land Rover', 'Volvo', 'Gene
sis', 'Jaguar']
Cylinders:  [np.float64(6.0), np.float64(8.0), np.float64(4.0), np.float64(nan), np.float64(3.
0), np.float64(0.0)]
Fuel Types:  ['Gasoline', 'Diesel', 'Hybrid', 'Electric', 'E85 Flex Fuel', 'PHEV Hybrid Fuel',
nan, 'Diesel (B20 capable)']
cars Body Type:  ['SUV', 'Pickup Truck', 'Sedan', 'Passenger Van', 'Cargo Van', nan, 'Hatchbac
k', 'Convertible', 'Minivan']
No. of Doors:  [np.float64(4.0), np.float64(3.0), np.float64(nan), np.float64(2.0), np.float64
(5.0)]
```

Note: You will see nan values in category is it because it is not yet cleaned

Data Cleaning

Data Droping and Imputation

1. Delete name and description column

In [256...
```
cleanedData = data.drop(['name', 'description'], axis=1)
cleanedData.head(2)
```

Out[256...

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
0	Jeep	Wagoneer	2024	74600.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	10.0	8-Speed Automatic	Series II	SUV
1	Jeep	Grand Cherokee	2024	50170.0	OHV	6.0	Gasoline	1.0	8-Speed Automatic	Laredo	SUV

Name column is to be deleted because the same data are already present in year, make, model, trim columns

2. Remove nan values from price

In [257...
```
cleanedData.dropna(subset=['price'], inplace=True)
```

3. Remove nan values from engine

In [258...
```
cleanedData[cleanedData['engine'].isna()]
```

Out[258...

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	bo
614	Honda	CR-V Hybrid	2025	42150.0	NaN	4.0	Gasoline	1.0	1-Speed CVT with Overdrive	Sport Touring	S
803	Jeep	Wagoneer	2024	73999.0	NaN	6.0	Gasoline	59.0	8-Speed Automatic	Series II	S

In [259...
```
cleanedData.loc[(cleanedData['make'] == "Honda") & (cleanedData['model'] == "CR-V Hybrid")][:
```

Out[259…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
109	Honda	CR-V Hybrid	2024	42005.0	16V GDI DOHC Hybrid	4.0	Hybrid	1.0	Automatic CVT	Sport Touring	SUV
304	Honda	CR-V Hybrid	2024	36900.0	16V GDI DOHC Hybrid	4.0	Hybrid	1.0	Automatic CVT	Sport	SUV
534	Honda	CR-V Hybrid	2024	40355.0	16V GDI DOHC Hybrid	4.0	Hybrid	68.0	Automatic CVT	Sport-L	SUV

In [260…

```
cleanedData[(cleanedData['make'] == "Jeep") & (cleanedData['model'] == "Wagoneer")& (cleanedD
```

Out[260…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
0	Jeep	Wagoneer	2024	74600.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	10.0	8-Speed Automatic	Series II	SUV
250	Jeep	Wagoneer	2024	87488.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	22.0	8-Speed Automatic	Series II	SUV
261	Jeep	Wagoneer	2024	72908.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	NaN	8-Speed Automatic	Series II	SUV

Note: As we can see from above rows containing nan values can be filled by locating similar type of models and makers, and here they both containing same engine as founded

1. `Honda` with `CR-V Hybrid` have `16V GDI DOHC Hybrid` engine and doors `4.0`.
2. `Jeep` with `Wagoneer` have `24V GDI DOHC Twin Turbo` engine.

In [261…

```
cleanedData.loc[614,'engine'] = "16V GDI DOHC Hybrid"
cleanedData.loc[614,'doors'] = np.float64(4.0)
cleanedData.loc[803,'engine'] = "24V GDI DOHC Twin Turbo"
```

In [262…

```
cleanedData.isna().sum()
```

Out[262…
```
make                0
model               0
year                0
price               0
engine              0
cylinders         102
fuel                7
mileage            34
transmission        2
trim                1
body                3
doors               6
exterior_color      5
interior_color     37
drivetrain          0
dtype: int64
```

4. Remove nan values from transmission

In [263…
```
cleanedData[cleanedData['transmission'].isna()]
```

Out[263…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim
725	Mercedes-Benz	EQS 450	2024	111245.0	c	NaN	Electric	10.0	NaN	Base 4MATIC
940	Ford	Transit-350	2024	52530.0	24V PDI DOHC Flexible Fuel	6.0	E85 Flex Fuel	1.0	NaN	148 WB Medium Roof Cargo

In [264…
```
cleanedData[(cleanedData['make'] == "Ford") & (cleanedData['model'] == "Transit-350") & (clea
```

Out[264…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
793	Ford	Transit-350	2023	57000.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	5581.0	10-Speed Automatic	Base	Cargo Van
805	Ford	Transit-350	2023	54525.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	0.0	10-Speed Automatic	NaN	Cargo Van

In [265…
```
cleanedData[(cleanedData['make'] == "Mercedes-Benz") & (cleanedData['model'] == "EQS 450") &
```

Out[265…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	b
253	Mercedes-Benz	EQS 450	2024	110395.0	c	NaN	Electric	5.0	Automatic	Base 4MATIC	Se
484	Mercedes-Benz	EQS 450	2024	117985.0	c	NaN	Electric	1.0	Automatic	Base 4MATIC	Se
725	Mercedes-Benz	EQS 450	2024	111245.0	c	NaN	Electric	10.0	NaN	Base 4MATIC	Se

Note: Same approach is used here looking at the same make, model, engine or body we can find same cars

1. `Mercedes-Benz` of model `EQS 450` and body `Sedan` have transmission `Automatic`
2. `Ford` of model `Transit-350` and engine `24V GDI DOHC Twin Turbo` have transmission `10-Speed Automatic`

In [266…

```
cleanedData.loc[725,'transmission'] = "Automatic"
cleanedData.loc[940,'transmission'] = "10-Speed Automatic"
```

In [267…

```
cleanedData.isna().sum()
```

Out[267…

```
make               0
model              0
year               0
price              0
engine             0
cylinders        102
fuel               7
mileage           34
transmission       0
trim               1
body               3
doors              6
exterior_color     5
interior_color    37
drivetrain         0
dtype: int64
```

5. Remove nan values from trim

In [268…

```
cleanedData[cleanedData['trim'].isna()]
```

Out[268…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body	d
805	Ford	Transit-350	2023	54525.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	0.0	10-Speed Automatic	NaN	Cargo Van	

In [269…

```
cleanedData[(cleanedData['make'] == "Ford") & (cleanedData['model'] == "Transit-350") & (clea
```

Out[269…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body	d
793	Ford	Transit-350	2023	57000.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	5581.0	10-Speed Automatic	Base	Cargo Van	
805	Ford	Transit-350	2023	54525.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	0.0	10-Speed Automatic	NaN	Cargo Van	

In [270…

```
cleanedData.loc[805,'trim'] = "base"
```

In [271…

```
cleanedData.isna().sum()
```

Out[271…

```
make               0
model              0
year               0
price              0
engine             0
cylinders        102
fuel               7
mileage           34
transmission       0
trim               0
body               3
doors              6
exterior_color     5
interior_color    37
drivetrain         0
dtype: int64
```

6. Remove nan values from body

In [272…

```
cleanedData[cleanedData['body'].isna()]
```

Out[272…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	bod
164	Dodge	Hornet	2024	41497.0	4 gasoline direct injection, DOHC, Multiair va...	4.0	Gasoline	11.0	6-Speed Automatic	R/T EAWD	Na
235	Dodge	Hornet	2024	41036.0	4 gasoline direct injection, DOHC, Multiair va...	4.0	Gasoline	5.0	6-Speed Automatic	R/T EAWD	Na
687	INFINITI	QX50	2024	49404.0	ER	4.0	Gasoline	7.0	(CVT) CONT VAR.	SPORT	Na

In [273…

```
cleanedData[(cleanedData['make'] == "INFINITI") & (cleanedData['model'] == "QX50")][:3]
```

Out[273…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	bc
167	INFINITI	QX50	2024	48350.0	o 2L I-4 port/direct injection, DOHC, variable...	4.0	Gasoline	3.0	Variable	LUXE	S
335	INFINITI	QX50	2024	45055.0	o 2L I-4 port/direct injection, DOHC, variable...	4.0	Gasoline	25.0	Variable	LUXE	S
687	INFINITI	QX50	2024	49404.0	ER	4.0	Gasoline	7.0	(CVT) CONT VAR.	SPORT	N

In [274…

```
cleanedData[(cleanedData['make'] == "Dodge") & (cleanedData['model'] == "Hornet") & (cleanedD…
```

Out[274…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
55	Dodge	Hornet	2024	42855.0	4 gasoline direct injection, DOHC, Multiair va...	4.0	Gasoline	5.0	6-Speed Automatic	R/T EAWD	SUV
164	Dodge	Hornet	2024	41497.0	4 gasoline direct injection, DOHC, Multiair va...	4.0	Gasoline	11.0	6-Speed Automatic	R/T EAWD	NaN
235	Dodge	Hornet	2024	41036.0	4 gasoline direct injection, DOHC, Multiair va...	4.0	Gasoline	5.0	6-Speed Automatic	R/T EAWD	NaN

In [275…

```
cleanedData.loc[164,'body'] = "SUV"
cleanedData.loc[235,'body'] = "SUV"
cleanedData.loc[687,'body'] = "SUV"
```

In [276…

```
cleanedData.isna().sum()
```

Out[276...
```
make                0
model               0
year                0
price               0
engine              0
cylinders         102
fuel                7
mileage            34
transmission        0
trim                0
body                0
doors               6
exterior_color      5
interior_color     37
drivetrain          0
dtype: int64
```

7. Remove nan values from fuel

In [277...
```python
cleanedData[cleanedData['fuel'].isna()]
```

Out[277...

	make	model	year	price	engine	cylinders	fuel	mileage	transmission
128	Subaru	Solterra	2024	39934.0	c	NaN	NaN	5.0	1-Speed Automatic
219	Honda	Prologue	2024	55800.0	c	NaN	NaN	NaN	1-Speed Automatic
315	Honda	Prologue	2024	56550.0	c	NaN	NaN	1.0	1-Speed Automatic
489	Honda	Prologue	2024	55800.0	c	NaN	NaN	NaN	1-Speed Automatic
490	Honda	Prologue	2024	55800.0	c	NaN	NaN	NaN	1-Speed Automatic
610	Chevrolet	Equinox EV	2024	47495.0	<dt>VIN</dt>\n 3GN7DNRPXRS232327	NaN	NaN	0.0	Automatic
726	Jaguar	I-PACE	2024	77053.0	d>\n\n \n <dt>VIN</dt>\n SADHM2S12R1...	NaN	NaN	8.0	Automatic

In [278...
```python
cleanedData['fuel'].value_counts()
```

Out[278...
```
fuel
Gasoline               647
Hybrid                 135
Electric                96
Diesel                  72
PHEV Hybrid Fuel        16
E85 Flex Fuel            5
Diesel (B20 capable)     1
Name: count, dtype: int64
```

Note: Generally all cars have fuel type gasoline so we are going to replace all nan value with `Gasoline`

In [279...
```python
cleanedData.fillna({'fuel':"Gasoline"},inplace=True)
```

8. Remove nan values from doors

In [280…
```
cleanedData['doors'].value_counts()
```

Out[280…
```
doors
4.0    926
3.0     37
2.0      9
5.0      1
Name: count, dtype: int64
```

- Generally every car comes with 4 doors so nan values in doors columns are going to fill with 4

In [281…
```
cleanedData.fillna({'doors':4},inplace=True)
```

In [282…
```
cleanedData.isna().sum()
```

Out[282…
```
make                0
model               0
year                0
price               0
engine              0
cylinders         102
fuel                0
mileage            34
transmission        0
trim                0
body                0
doors               0
exterior_color      5
interior_color     37
drivetrain          0
dtype: int64
```

9. Remove nan values from exterior_colors

In [283…
```
cleanedData[cleanedData['exterior_color'].isna()][:3]
```

Out[283…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim
117	Jeep	Wrangler	2024	59456.0	ar 3.6L V-6 DOHC, variable valve control, regu...	6.0	Gasoline	15.0	Automatic	4-Door Sahara 4x4
137	Acura	ZDX	2024	69850.0	c	0.0	Electric	0.0	Automatic	A-SPEC
373	Mercedes-Benz	EQS 450	2024	114850.0	c	NaN	Electric	8.0	1-Speed Automatic	Base 4MATIC

In [284…
```
cleanedData['exterior_color'].value_counts()
```

Out[284…
```
exterior_color
Bright White Clearcoat      80
Black                       31
White                       29
Gray                        25
Summit White                25
                            ..
Aspen White / Super Black    1
Jungle Green                 1
Cactus Gray                  1
Pearl White Tricoat          1
Wheatland Yellow             1
Name: count, Length: 262, dtype: int64
```

- It is going to be filled with `Bright White Clearcoat` because most of the cars used it

In [285…
```
cleanedData.fillna({'exterior_color': 'Bright White Clearcoat'},inplace=True)
```

10. Remove nan values from cylinders

In [286…
```
cleanedData[cleanedData['cylinders'].isna()][:3]
```

Out[286…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body	d
14	Chevrolet	Blazer EV	2024	51695.0	c	NaN	Electric	4.0	1-Speed Automatic	2LT	SUV	
28	Chevrolet	Blazer EV	2024	52190.0	c	NaN	Electric	6.0	1-Speed Automatic	2LT	SUV	
33	Kia	EV6	2024	49820.0	c	NaN	Electric	13.0	Automatic	GT	SUV	

In [287…
```
cleanedData[cleanedData['fuel'] == "Gasoline"]['cylinders'].value_counts()
```

Out[287…
```
cylinders
4.0    336
6.0    203
8.0     80
3.0     27
Name: count, dtype: int64
```

- We are going to fill `4` in cylinders whose `cylinders` are `Nan` and fuel type is `Gasoline`

In [288…
```
cleanedData.loc[(cleanedData['cylinders'].isna()) & (cleanedData['fuel'] == 'Gasoline'),'cyli
```

- Correctly assign `Electric` to EVs and 0 cylinders before general imputation.
- This is based on the observation that EVs often have engine type `C`.

In [289…
```
cleanedData.loc[cleanedData['engine'] == 'C', 'fuel'] = 'Electric'
cleanedData.loc[(cleanedData['cylinders'].isna()) & (cleanedData['fuel'] == 'Electric'),'cyli
```

11. Remove nan values from mileage

In [290…
```
cleanedData[cleanedData['mileage'].isna()][:3]
```

Out[290…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim
27	Chrysler	Pacifica	2024	48705.0	24V MPFI DOHC	6.0	Gasoline	NaN	9-Speed Automatic	Touring-L
47	Subaru	Outback	2024	44354.0	16V GDI DOHC Turbo	4.0	Gasoline	NaN	Automatic CVT	Wilderness
63	Jeep	Grand Cherokee L	2024	51360.0	24V MPFI DOHC	6.0	Gasoline	NaN	8-Speed Automatic	Limited

In [291…

```
cleanedData['mileage'].value_counts()
```

Out[291…

```
mileage
5.0      113
0.0      109
10.0     103
1.0       58
6.0       50
        ... 
241.0      1
66.0       1
41.0       1
141.0      1
296.0      1
Name: count, Length: 91, dtype: int64
```

- Generally the milage is 5.0 so we are going to replace it with nan values

In [292…

```
cleanedData.fillna({'mileage': 5.0},inplace=True)
```

12. Removing unusual data values in engine

In [293…

```
# Drop rows where 'engine' contains the '<dt' tag (case-insensitive)
mask = cleanedData['engine'].astype(str).str.contains(r'<dt', case=False, na=False)
print(f"Removing {mask.sum()} rows containing '<dt' in engine")
# Optional inspect
display(cleanedData.loc[mask, ['engine']].head(10))
# Drop and reset index
cleanedData = cleanedData.loc[~mask].reset_index(drop=True)
print("New shape:", cleanedData.shape)
```

```
Removing 8 rows containing '<dt' in engine
```

	engine
195	>\n\n \n <dt>VIN</dt>\n ZACNDFAN0R3A...
255	dd>\n\n \n <dt>VIN</dt>\n 1V2BMPE85R...
474	>\n\n \n <dt>VIN</dt>\n ZACNDFAN0R3A...
610	<dt>VIN</dt>\n 3GN7DNRPXRS232327
685	<dt>VIN</dt>\n 1FMUK7HH1SGA05728
705	<dt>VIN</dt>\n 3C63R3HLXRG198198
726	d>\n\n \n <dt>VIN</dt>\n SADHM2S12R1...
893	d>\n\n \n <dt>VIN</dt>\n 7FARS4H71SE...

```
New shape: (971, 15)
```

13. Remove nan values from interior_colors

In [294...
```
cleanedData['interior_color'].value_counts()
```

Out[294...
```
interior_color
Black           492
Global Black     83
Gray             76
Jet Black        45
Ebony            37
               ...
Caramel           1
gray              1
Dark Palazzo      1
Gray/Black        1
Navy Pier         1
Name: count, Length: 88, dtype: int64
```

- Here `Black` interior is the most commone one

In [295...
```
cleanedData.fillna({'interior_color':'Black'},inplace=True)
```

In [296...
```
cleanedData.isna().sum()
```

Out[296...
```
make              0
model             0
year              0
price             0
engine            0
cylinders         0
fuel              0
mileage           0
transmission      0
trim              0
body              0
doors             0
exterior_color    0
interior_color    0
drivetrain        0
dtype: int64
```

In [297...
```
cleanedData.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 971 entries, 0 to 970
Data columns (total 15 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   make             971 non-null    object 
 1   model            971 non-null    object 
 2   year             971 non-null    int64  
 3   price            971 non-null    float64
 4   engine           971 non-null    object 
 5   cylinders        971 non-null    float64
 6   fuel             971 non-null    object 
 7   mileage          971 non-null    float64
 8   transmission     971 non-null    object 
 9   trim             971 non-null    object 
 10  body             971 non-null    object 
 11  doors            971 non-null    float64
 12  exterior_color   971 non-null    object 
 13  interior_color   971 non-null    object 
 14  drivetrain       971 non-null    object 
dtypes: float64(4), int64(1), object(10)
memory usage: 113.9+ KB
```

Detecting Outliers

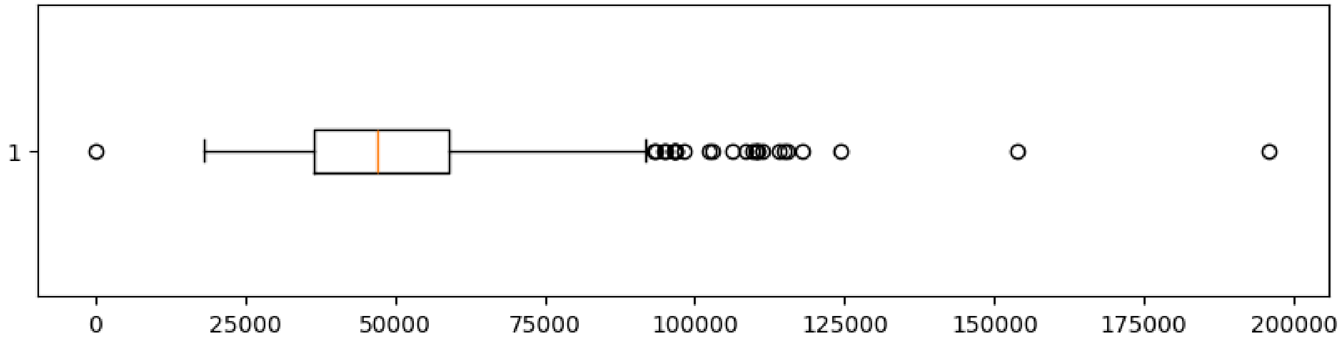
Possible Outliers can exist in:

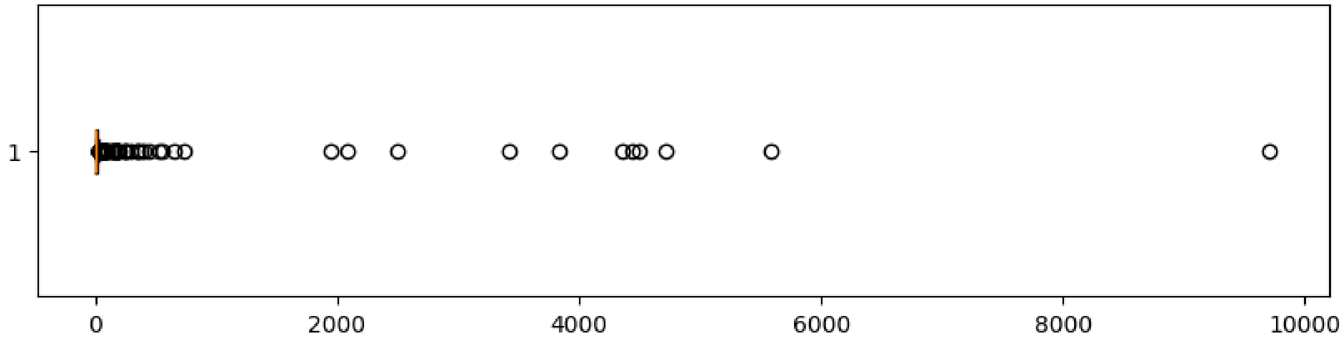
- price
- mileage

Before Removing Outliers

In [298…

```
fig, axs = plt.subplots(2,1, figsize=(10, 5)) # 2 rows, 2 columns
axs[0].boxplot(cleanedData['price'],orientation='horizontal')
axs[1].boxplot(cleanedData['mileage'],orientation='horizontal')
plt.show()
```





In [299…

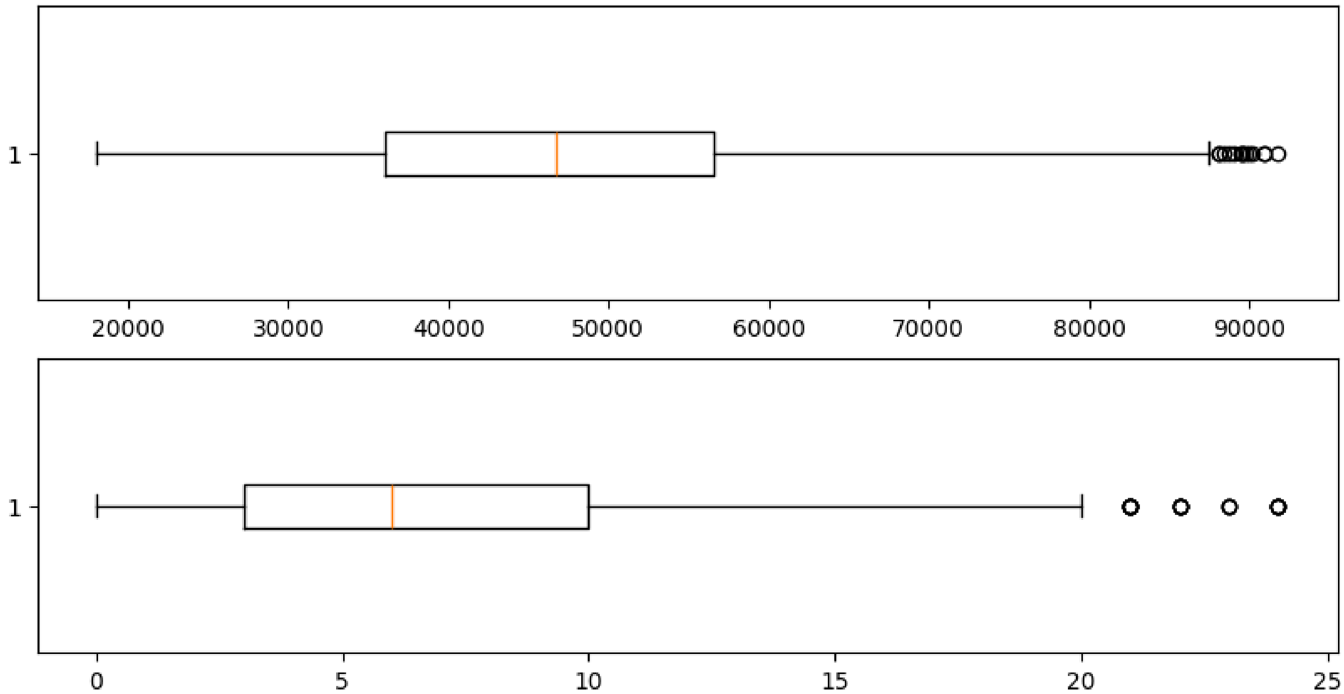
```
# Calculate IQR for the 'price' column
Q1_price = cleanedData['price'].quantile(0.25)
Q3_price = cleanedData['price'].quantile(0.75)
IQR_price = Q3_price - Q1_price
lower_bound_price = Q1_price - 1.5 * IQR_price
```

```python
upper_bound_price = Q3_price + 1.5 * IQR_price

# Calculate IQR for the 'mileage' column
Q1_mileage = cleanedData['mileage'].quantile(0.25)
Q3_mileage = cleanedData['mileage'].quantile(0.75)
IQR_mileage = Q3_mileage - Q1_mileage
lower_bound_mileage = Q1_mileage - 1.5 * IQR_mileage
upper_bound_mileage = Q3_mileage + 1.5 * IQR_mileage

# Filter the DataFrame to remove outliers from both columns
cleanedData = cleanedData[
    (cleanedData['price'] >= lower_bound_price) &
    (cleanedData['price'] <= upper_bound_price) &
    (cleanedData['mileage'] >= lower_bound_mileage) &
    (cleanedData['mileage'] <= upper_bound_mileage)
]
```

After Removing Outliers

In [300…

```python
fig, axs = plt.subplots(2,1, figsize=(10, 5)) # 2 rows, 2 columns
axs[0].boxplot(cleanedData['price'],orientation='horizontal')
axs[1].boxplot(cleanedData['mileage'],orientation='horizontal')
plt.show()
```



Shape now after cleaning the data

In [301…

```python
shape = cleanedData.shape
print(f"No. of rows: {shape[0]}")
print(f"No. of rows removed: {data.shape[0]-shape[0]}")
```

```
No. of rows: 840
No. of rows removed: 162
```

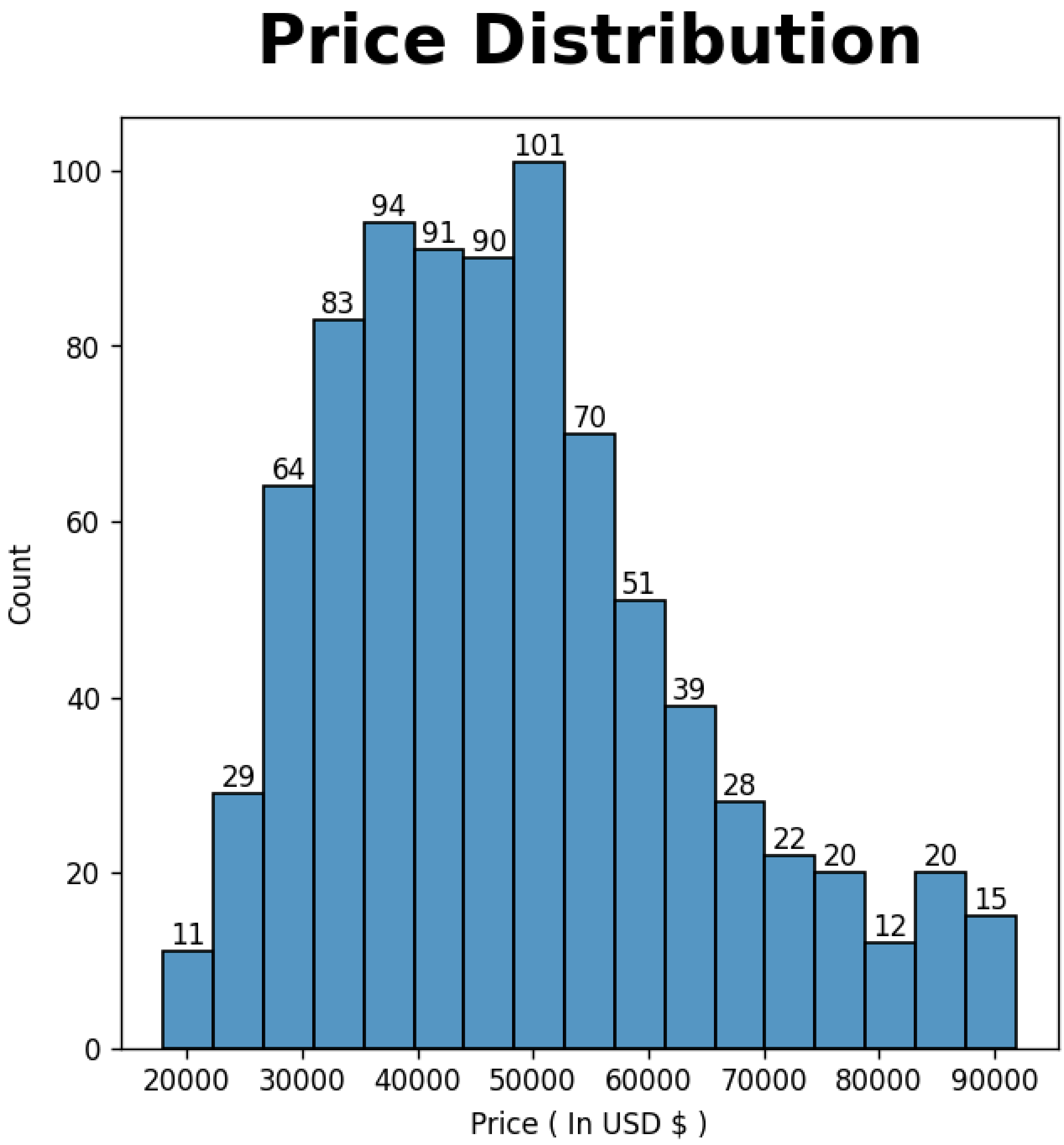
EDA

1. Create a Histogram of Price to see the distribution of price

In [302…

```python
plt.figure(figsize=(6,6),dpi=120)
ax = sns.histplot(cleanedData['price'])
ax.bar_label(ax.containers[0],fontsize = 10)
ax.set_xlabel("Price ( In USD $ )")
```

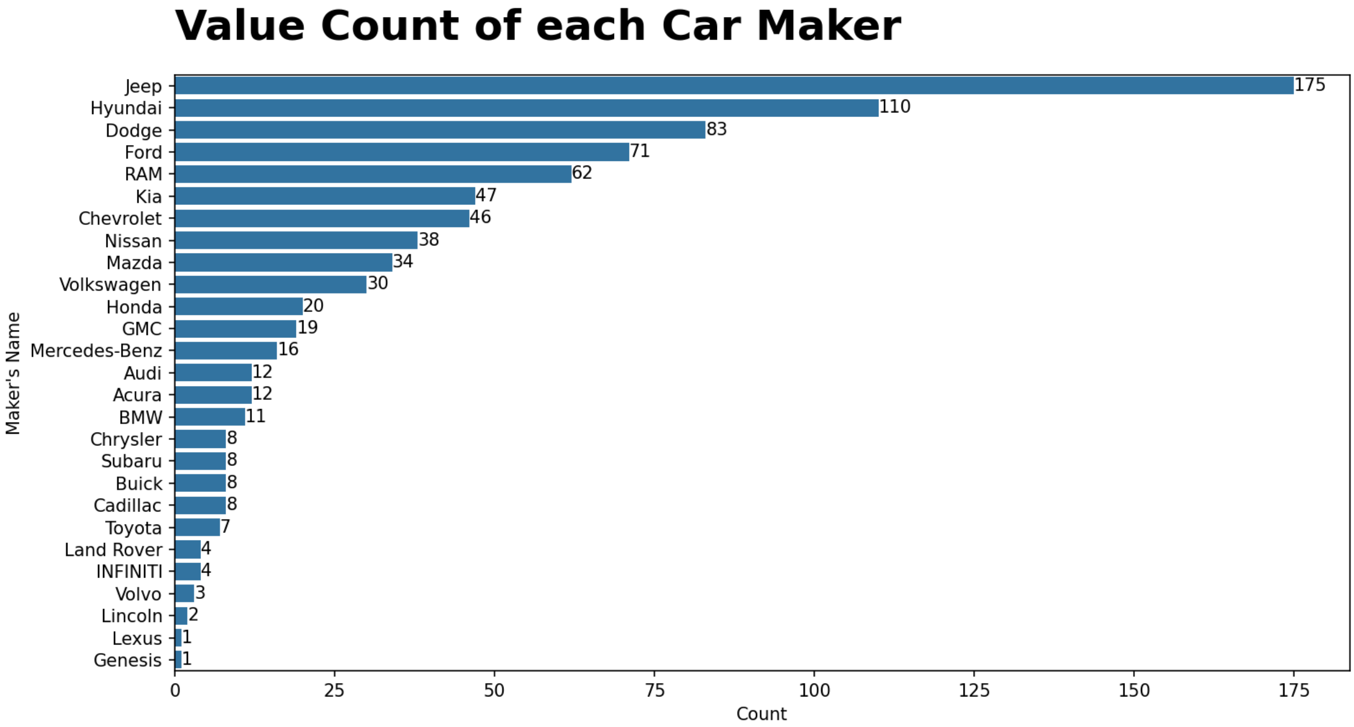
```
ax.set_ylabel("Count")
ax.set_title("Price Distribution",fontdict={'weight':"bold",'size':24},pad=20)
plt.show()
```



2. We will create a Bar graph of `make` feature to how many cars in total is made by each maker

In [303…

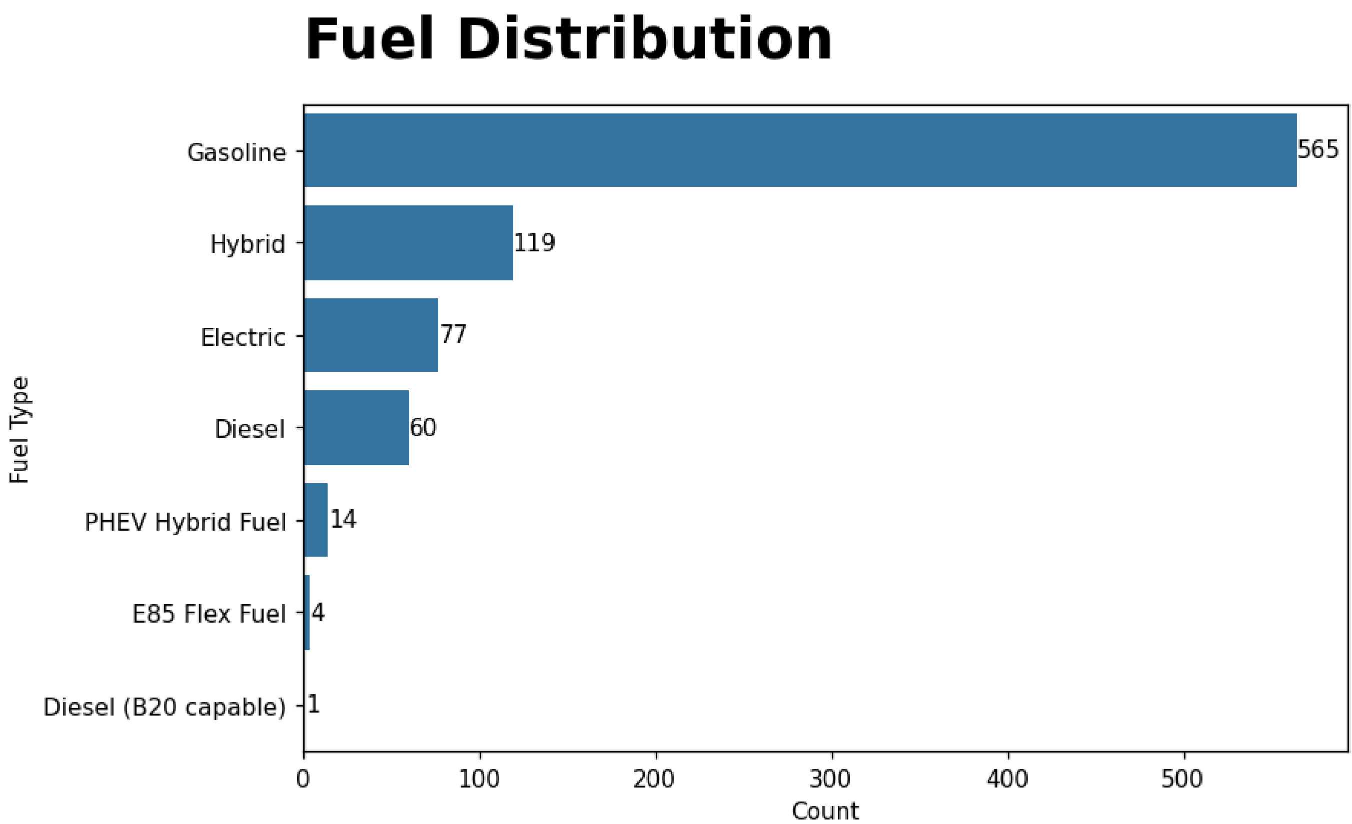
```
plt.figure(figsize=(11,6),dpi=150)

ax = sns.barplot(data=cleanedData['make'].value_counts(),errorbar=None,estimator="sum",orient
ax.bar_label(ax.containers[0],fontsize = 10)
ax.set_xlabel("Count")
ax.set_ylabel("Maker's Name")
ax.set_title("Value Count of each Car Maker",loc="left",fontdict={'weight':"bold",'size':24},

plt.tight_layout()
plt.show()
```



3. Create a Histogram of fuel

In [304…

```
plt.figure(figsize=(8,5),dpi=110)
ax = sns.barplot(cleanedData['fuel'].value_counts(),errorbar=None,orient='y')
ax.bar_label(ax.containers[0],fontsize = 10)
ax.set_xlabel("Count")
ax.set_ylabel("Fuel Type")
ax.set_title("Fuel Distribution",fontdict={'weight':"bold",'size':24},pad=20,loc='left')
plt.show()
```

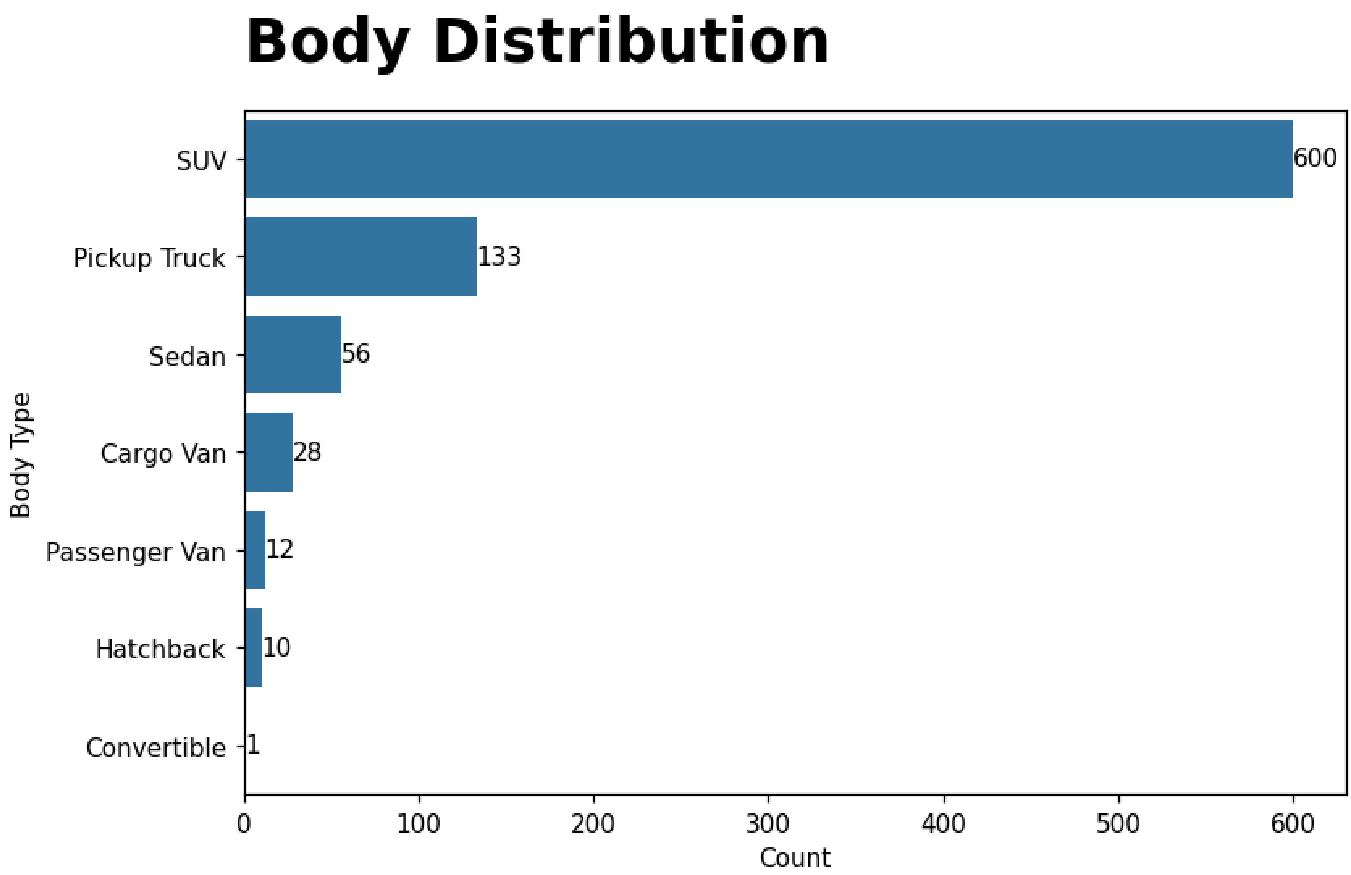


4. Create a Bar graph of `Body` do see general body type of all cars

In [305…

```
plt.figure(figsize=(8,5),dpi=110)
ax = sns.barplot(cleanedData['body'].value_counts(),errorbar=None,orient='y')
ax.bar_label(ax.containers[0],fontsize = 10)
```

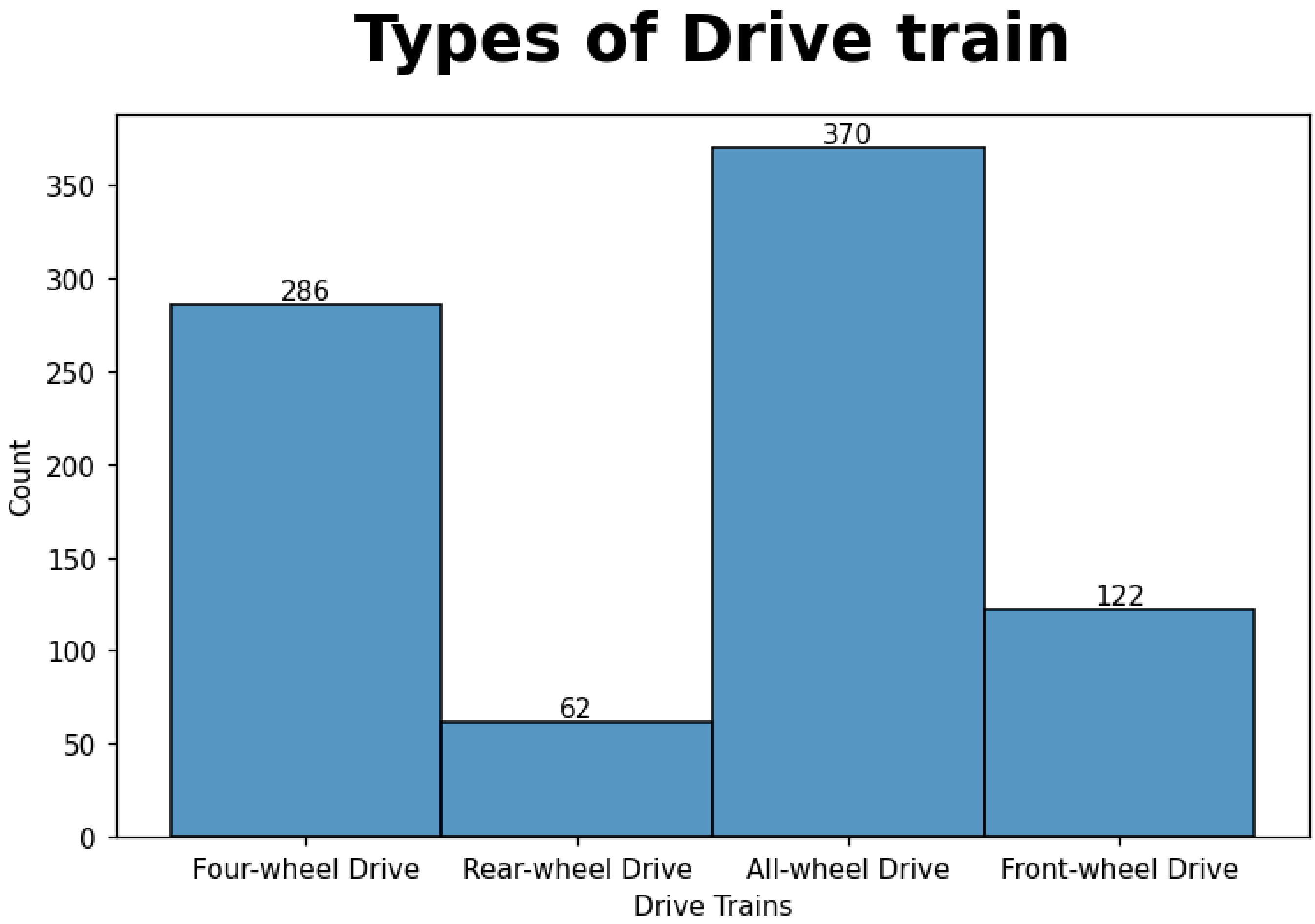
```
ax.set_xlabel("Count")
ax.set_ylabel("Body Type")
ax.set_title("Body Distribution",fontdict={'weight':"bold",'size':24},pad=20,loc='left')
plt.show()
```



5. Create a Bar Graph of `drivetrain`

In [306…

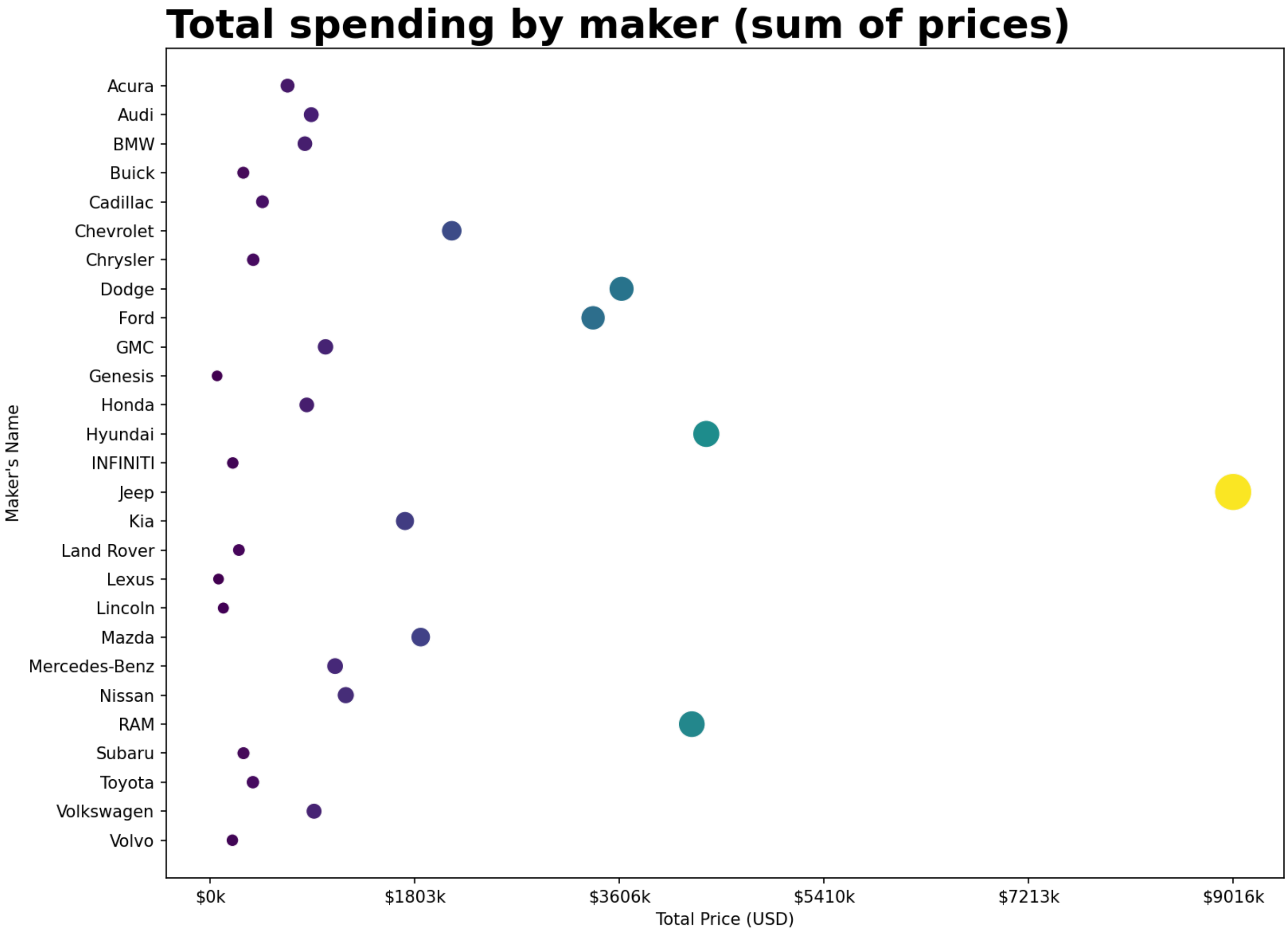
```
plt.figure(figsize=(7,5),dpi=110)

ax = sns.histplot(cleanedData['drivetrain'])
ax.bar_label(ax.containers[0],fontsize = 10)
ax.tick_params(axis='x')
ax.set_xlabel("Drive Trains")
ax.set_ylabel("Count")
ax.set_title("Types of Drive train",fontdict={'weight':"bold",'size':24},pad=20)
plt.tight_layout()
plt.show()
```



6. Create a scatter plot where x axis makers name in ascending order of price and y axis show price (The idea to show how much each company spend)

In [307…

```
import matplotlib.ticker as ticker

make_price = cleanedData.groupby('make', as_index=False)['price'].sum()
make_price
plt.figure(figsize=(11,8), dpi=150)
ax = sns.scatterplot(
    data=make_price,
    x='price',
    y='make',
    size='price',
    hue='price',
    sizes=(50, 500),
    palette='viridis',
    legend=False
)

max_price = make_price['price'].max()
ticks = np.linspace(0, max_price, 6)
ax.set_xticks(ticks)
ax.xaxis.set_major_formatter(ticker.FuncFormatter(lambda x, pos: f'${x/1000:.0f}k'))

ax.set_xlabel('Total Price (USD)')
ax.set_ylabel("Maker's Name")
ax.set_title("Total spending by maker (sum of prices)", loc='left', fontdict={'weight':'bold'
plt.tight_layout()
plt.show()
```



Feature Engineering

1. Make a Prediction data for Feature Engineering and Model training

In [308…
```
predictionData = cleanedData[['make', 'model', 'year', 'price', 'engine', 'cylinders', 'fuel'
```

In [309…
```
predictionData.head()
```

Out[309…

	make	model	year	price	engine	cylinders	fuel	mileage	transmission	trim	body
0	Jeep	Wagoneer	2024	74600.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	10.0	8-Speed Automatic	Series II	SUV
1	Jeep	Grand Cherokee	2024	50170.0	OHV	6.0	Gasoline	1.0	8-Speed Automatic	Laredo	SUV
4	RAM	3500	2024	81663.0	24V DDI OHV Turbo Diesel	6.0	Diesel	10.0	6-Speed Automatic	Laramie	Pickup Truck
6	Jeep	Wagoneer	2024	63862.0	24V GDI DOHC Twin Turbo	6.0	Gasoline	5.0	8-Speed Automatic	Base	SUV
7	Ford	F-350	2024	89978.0	32V DDI OHV Turbo Diesel	8.0	Diesel	15.0	10-Speed Automatic	Lariat Super Duty	Pickup Truck

2. Engine Feature Extraction

In [310…

```
# --- Feature Engineering from 'engine' column ---
predictionData['engine_liters'] = predictionData['engine'].str.extract(r'(\d\.?\d*)L', flags=
predictionData['is_turbo'] = predictionData['engine'].str.contains('Turbo', case=False, na=Fa
predictionData['is_hybrid'] = predictionData['engine'].str.contains('Hybrid', case=False, na=
predictionData['valve_count'] = predictionData['engine'].str.extract(r'(\d{1,2})V', flags=re.


# --- Handle Missing Values in New Columns (Warning-Free Method) ---
# Reassign the column instead of using inplace=True
median_liters = predictionData['engine_liters'].median()
predictionData['engine_liters'] = predictionData['engine_liters'].fillna(median_liters)

median_valves = predictionData['valve_count'].median()
predictionData['valve_count'] = predictionData['valve_count'].fillna(median_valves)

# This syntax is also fine for the binary flags
predictionData['is_turbo'] = predictionData['is_turbo'].fillna(0)
predictionData['is_hybrid'] = predictionData['is_hybrid'].fillna(0)


# --- Clean Up ---
# Drop the original 'engine' column as it's no longer needed
predictionData.drop('engine', axis=1, inplace=True)

print("New engineered features:")
print(predictionData[['engine_liters', 'is_turbo', 'is_hybrid', 'valve_count']].head())
```

```
New engineered features created without warnings:
   engine_liters  is_turbo  is_hybrid  valve_count
0            3.6         1          0         24.0
1            3.6         0          0         16.0
4            3.6         1          0         24.0
6            3.6         1          0         24.0
7            3.6         1          0         32.0
```

3. Trim Feature Extraction

In [319…

```
# --- Feature Engineering for 'trim' ---

# Calculate how many times each trim appears
trim_counts = predictionData['trim'].value_counts()

# Identify trims that appear less than, say, 5 times
rare_trims = trim_counts[trim_counts < 5].index

# Replace these rare trims with the category 'Other'
predictionData['trim_cleaned'] = predictionData['trim'].replace(rare_trims, 'Other')

# Drop the original trim column
predictionData.drop('trim', axis=1, inplace=True)
```

4. Feature extraction of Model

In [323…

```
# --- Feature Engineering for 'model' ---

# Calculate how many times each model appears
model_counts = predictionData['model'].value_counts()

# Identify models that appear less than, say, 10 times
rare_models = model_counts[model_counts < 10].index

# Replace these rare models with the category 'Other'
predictionData['model_cleaned'] = predictionData['model'].replace(rare_models, 'Other')

# Now you can one-hot encode 'model_cleaned' instead of the original 'model'
# Don't forget to drop the original 'model' column
predictionData.drop('model', axis=1, inplace=True)
```

5. Feature Extraction of transmission

In [324…

```
# --- Improved Feature Engineering for 'transmission' ---

# 1. Extract the number of speeds (gears) - This part remains the same.
predictionData['gears'] = predictionData['transmission'].str.extract(r'(\d{1,2})-Speed', flag

# 2. Create a categorical 'transmission_type' column
# Define conditions for each transmission type. Order is important: check for CVT first.
conditions = [
    predictionData['transmission'].str.contains('CVT', case=False, na=False),
    predictionData['transmission'].str.contains('Automatic', case=False, na=False)
]

# Define the values to assign for each condition
choices = ['CVT', 'Automatic']

# Create the new column using np.select
# If a value is neither CVT nor Automatic, it will be labeled 'Other'
predictionData['transmission_type'] = np.select(conditions, choices, default='Other')
```

```
# --- Handle Missing Values and Clean Up ---

# Fill any missing gear counts with the median
predictionData['gears'] = predictionData['gears'].fillna(predictionData['gears'].median())

# Drop the original transmission column
predictionData.drop('transmission', axis=1, inplace=True)

# Now, one-hot encode the new 'transmission_type' column along with your other categoricals.

print("Improved transmission features:")
print(predictionData[['gears', 'transmission_type']].head())
```

```
Improved transmission features:
   gears transmission_type
0    8.0         Automatic
1    8.0         Automatic
4    6.0         Automatic
6    8.0         Automatic
7   10.0         Automatic
```

6. Add an Age feauture which shows the age of a car

In [311…

```
# Example
current_year = 2024
predictionData.loc[:,'age'] = current_year - predictionData['year']
```

7. Perform Feature Encoding on make, fuel, body, drive train

In [327…

```
# Assume 'predictionData' is your DataFrame after feature engineering
encodedData = predictionData.copy()

# List of all columns you want to encode
categorical_cols = [
    'make', 'fuel', 'body', 'drivetrain',
    'model_cleaned', 'trim_cleaned', 'transmission_type'
]

# Loop through the columns and apply the encoder
for col in categorical_cols:
    le = LabelEncoder()
    encodedData[col] = le.fit_transform(encodedData[col])

print("Data after Label Encoding:")
print(encodedData.head())
```

```
Data after Label Encoding:
   make  year    price  cylinders  fuel  mileage  body  doors  drivetrain  \
0    14  2024  74600.0        6.0     4     10.0     5    4.0           1
1    14  2024  50170.0        6.0     4      1.0     5    4.0           1
4    22  2024  81663.0        6.0     0     10.0     4    4.0           1
6    14  2024  63862.0        6.0     4      5.0     5    4.0           3
7     8  2024  89978.0        8.0     0     15.0     4    4.0           1

   engine_liters  is_turbo  is_hybrid  valve_count  age  trim_cleaned  \
0            3.6         1          0         24.0    0            44
1            3.6         0          0         16.0    0            20
4            3.6         1          0         24.0    0            18
6            3.6         1          0         24.0    0             7
7            3.6         1          0         32.0    0            25

   model_cleaned  gears  transmission_type
0             23    8.0                  0
1              8    8.0                  0
4              1    6.0                  0
6             23    8.0                  0
7             17   10.0                  0
```

Data Preprocessing

Train and Test Data

In [329…

```
X = encodedData.drop(['price'],axis=1)
y = encodedData['price']

X_train,X_test,y_train,y_test = train_test_split(X,y,random_state=45,train_size=0.8,test_size
```

Data Scaling

In [330…

```
scaler = StandardScaler()

# 1. Fit on training data and transform it
X_train_scaled = scaler.fit_transform(X_train)

# 2. Use the SAME scaler to transform the test data
X_test_scaled = scaler.transform(X_test)

X_train_scaled_df = pd.DataFrame(X_train_scaled,columns=X_train.columns)
X_test_scaled_df = pd.DataFrame(X_test_scaled,columns=X_test.columns)
```

Model Selection and Evaluation

For this project we are going to use Linear Regression

In [353…

```
linearModel = LinearRegression()

linearModel.fit(X_train_scaled_df,y_train)

prediction = linearModel.predict(X_test_scaled_df)

mae = mean_absolute_error(y_test, prediction)
rmse = np.sqrt(mean_squared_error(y_test, prediction))
r2 = r2_score(y_test, prediction)

print(f"MAE: ${mae:,.2f}")
```

```
print(f"RMSE: ${rmse:,.2f}")
print(f"R-squared: {r2:.4f}")
```

```
MAE: $10,151.26
RMSE: $12,804.19
R-squared: 0.2889
```

In [341…

```
regressor = RandomForestRegressor(n_estimators=10, random_state=0, oob_score=True)
regressor.fit(X_train_scaled, y_train)

tunedregressor = RandomForestRegressor(n_estimators=300, max_features=0.24,random_state=0, oo
tunedregressor.fit(X_train_scaled, y_train)
```

```
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:611: UserWarning: Some inputs do not have OOB scores. This probably means too few tre
es were used to compute any reliable OOB estimates.
  warn(
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
```

Out[341…

▾ RandomForestRegressor

▶ Parameters

In [333…

```
predictions = regressor.predict(X_test_scaled)

oob_score = regressor.oob_score_
mae = mean_absolute_error(y_test, predictions)
rmse = np.sqrt(mean_squared_error(y_test, predictions))
r2 = r2_score(y_test, predictions)

print(f'Out-of-Bag Score: {oob_score}')
print(f"MAE: ${mae:,.2f}")
print(f"RMSE: ${rmse:,.2f}")
print(f"R-squared: {r2:.4f}")
```

```
Out-of-Bag Score: 0.7102655005935559
MAE: $4,246.58
RMSE: $6,765.76
R-squared: 0.8014
```

In [342…

```
predictions = tunedregressor.predict(X_test_scaled)

oob_score = tunedregressor.oob_score_
mae = mean_absolute_error(y_test, predictions)
rmse = np.sqrt(mean_squared_error(y_test, predictions))
r2 = r2_score(y_test, predictions)

print(f'Out-of-Bag Score: {oob_score}')
print(f"MAE: ${mae:,.2f}")
print(f"RMSE: ${rmse:,.2f}")
print(f"R-squared: {r2:.4f}")
```

```
Out-of-Bag Score: 0.8529480528464308
MAE: $3,919.60
RMSE: $6,353.10
R-squared: 0.8249
```

In [343…

```
sample = X_test.iloc[0:1]
```

```python
samplePrice = y_test.iloc[0:1]
prediction = tunedregressor.predict(scaler.transform(sample))

sample_dict = sample.iloc[0].to_dict()

print(f"\nSample Data: {sample_dict}")
print(f"Predicted Price: {prediction[0]}\nActual Price: {samplePrice.values[0]}")
```

```
Sample Data: {'make': 14.0, 'year': 2024.0, 'cylinders': 4.0, 'fuel': 5.0, 'mileage': 5.0, 'bo
dy': 5.0, 'doors': 4.0, 'drivetrain': 1.0, 'engine_liters': 3.6, 'is_turbo': 1.0, 'is_hybrid':
1.0, 'valve_count': 16.0, 'age': 0.0, 'trim_cleaned': 45.0, 'model_cleaned': 25.0, 'gears': 8.
0, 'transmission_type': 0.0}
Predicted Price: 51541.73333333333
Actual Price: 50755.0
```

If we add 3000$ in the predicted price it will match the price of actual price

Hyper parameter tuning for Randome Forest Regressor

Only to be used when regressor is not runned

In [336…

```python
# # Define the search space for continuous hyperparameters
# # For example, 'n_estimators' (integer) and 'max_features' (continuous)
# param_distributions = {
#     'n_estimators': [100, 200, 300],
#     'max_features': uniform(0.1, 0.9) # Continuous range from 0.1 to 1.0 (0.1 + 0.9)
# }

# # Perform Randomized Search
# random_search = RandomizedSearchCV(
#     estimator=regressor,
#     param_distributions=param_distributions,
#     n_iter=50, # Number of random combinations to try
#     cv=5,       # 5-fold cross-validation
#     scoring='neg_mean_squared_error', # Metric for evaluation
#     random_state=42
# )

# # Fit the search to your data
# random_search.fit(X_train_scaled, y_train)

# # Get the best hyperparameters
# best_params = random_search.best_params_
# best_params
```

```
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
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C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
amples.
  y_type = type_of_target(y)
C:\Users\Shaurya Srivastava\AppData\Roaming\Python\Python313\site-packages\sklearn\ensemble\_f
orest.py:513: UserWarning: The number of unique classes is greater than 50% of the number of s
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Out[336…

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{'max_features': np.float64(0.2403950683025824), 'n_estimators': 300}
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