st125066_A2_Assignment

September 6, 2024

1 Car Price Prediction

The goal is to predict car price

The followings describe the features in the dataset

- **name** : Brand and series of the car
- **Year** : The year when the car is produced
- **selling_price** : Selling price of the car
- **km_driven** : The amount of kilometer that the car was driven before selling the car
- **fuel** : The type of fuel used in the car
- **seller_type** : The channel through which the deal of car is organized
- **transmission** : The gear transmission type that is used in the car
- **owner** : The number of times that the car was traded before
- **mileage** : The kilometers that can be traveled by using the fuel of 1 liter or 1 kg
- **engine** : The size of the engine
- **max_power** : The maximum power of engine measured in bhp. (BHP - the brake horsepower is the horse power after taking account of losses due to friction)
- **torque** : Torque
- **seats** : The number of seats in the car

1.1 Importing libraries

[ ]:
```
import sys
sys.path.append('/home/knl/.local/lib/python3.10/site-packages')
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
import os

warnings.filterwarnings('ignore')
```

[ ]:
```
import matplotlib
np.__version__, pd.__version__, sns.__version__, matplotlib.__version__
```

[ ]:
```
('2.1.0', '2.2.2', '0.13.2', '3.9.2')
```

1.2 1. Load data

[ ]:
```
# Load the data
df = pd.read_csv(os.path.join(os.getcwd(),"data/Cars.csv"))
```

[ ]:
```
# print the first rows of data
df.head()
```

[ ]:
```
                          name  year  selling_price  km_driven    fuel  \
0        Maruti Swift Dzire VDI  2014         450000     145500  Diesel
1  Skoda Rapid 1.5 TDI Ambition  2014         370000     120000  Diesel
2      Honda City 2017-2020 EXi  2006         158000     140000  Petrol
3     Hyundai i20 Sportz Diesel  2010         225000     127000  Diesel
4        Maruti Swift VXI BSIII  2007         130000     120000  Petrol

  seller_type transmission         owner     mileage   engine   max_power  \
0  Individual       Manual   First Owner   23.4 kmpl  1248 CC      74 bhp
1  Individual       Manual  Second Owner  21.14 kmpl  1498 CC  103.52 bhp
2  Individual       Manual   Third Owner   17.7 kmpl  1497 CC      78 bhp
3  Individual       Manual   First Owner   23.0 kmpl  1396 CC      90 bhp
4  Individual       Manual   First Owner   16.1 kmpl  1298 CC    88.2 bhp

                     torque  seats
0            190Nm@ 2000rpm    5.0
1       250Nm@ 1500-2500rpm    5.0
2     12.7@ 2,700(kgm@ rpm)    5.0
3  22.4 kgm at 1750-2750rpm    5.0
4     11.5@ 4,500(kgm@ rpm)    5.0
```

[ ]:
```
# Check the shape of your data
df.shape
```

[ ]:
```
(8128, 13)
```

[ ]:
```
# Statistical info
df.describe()
```

[ ]:
```
              year  selling_price     km_driven        seats
count  8128.000000   8.128000e+03  8.128000e+03  7907.000000
mean   2013.804011   6.382718e+05  6.981951e+04     5.416719
std       4.044249   8.062534e+05  5.655055e+04     0.959588
min    1983.000000   2.999900e+04  1.000000e+00     2.000000
25%    2011.000000   2.549990e+05  3.500000e+04     5.000000
50%    2015.000000   4.500000e+05  6.000000e+04     5.000000
75%    2017.000000   6.750000e+05  9.800000e+04     5.000000
max    2020.000000   1.000000e+07  2.360457e+06    14.000000
```

[ ]:
```
# Check Dtypes of data
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8128 entries, 0 to 8127
Data columns (total 13 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   name           8128 non-null   object
 1   year           8128 non-null   int64
 2   selling_price  8128 non-null   int64
 3   km_driven      8128 non-null   int64
 4   fuel           8128 non-null   object
 5   seller_type    8128 non-null   object
 6   transmission   8128 non-null   object
 7   owner          8128 non-null   object
 8   mileage        7907 non-null   object
 9   engine         7907 non-null   object
 10  max_power      7913 non-null   object
 11  torque         7906 non-null   object
 12  seats          7907 non-null   float64
dtypes: float64(1), int64(3), object(9)
memory usage: 825.6+ KB
```

[ ]:
```
# Check the column names
df.columns
```

[ ]:
```
Index(['name', 'year', 'selling_price', 'km_driven', 'fuel', 'seller_type',
       'transmission', 'owner', 'mileage', 'engine', 'max_power', 'torque',
       'seats'],
      dtype='object')
```

1.3 2. Exploratory Data Analysis

EDA is an essential step to inspect the data, so to better understand nature of the given data.

1.3.1 2.1 Data Cleansing

We need to perform data cleansing as the data is not tidy yet.

[ ]:
```
df.columns
```

[ ]:
```
Index(['name', 'year', 'selling_price', 'km_driven', 'fuel', 'seller_type',
       'transmission', 'owner', 'mileage', 'engine', 'max_power', 'torque',
       'seats'],
      dtype='object')
```

[ ]:
```
df.head(10)
```

[ ]:

	name	year	selling_price	km_driven
0	Maruti Swift Dzire VDI	2014	450000	145500
1	Skoda Rapid 1.5 TDI Ambition	2014	370000	120000
2	Honda City 2017-2020 EXi	2006	158000	140000
3	Hyundai i20 Sportz Diesel	2010	225000	127000
4	Maruti Swift VXI BSIII	2007	130000	120000
5	Hyundai Xcent 1.2 VTVT E Plus	2017	440000	45000
6	Maruti Wagon R LXI DUO BSIII	2007	96000	175000
7	Maruti 800 DX BSII	2001	45000	5000
8	Toyota Etios VXD	2011	350000	90000
9	Ford Figo Diesel Celebration Edition	2013	200000	169000

	fuel	seller_type	transmission	owner	mileage	engine
0	Diesel	Individual	Manual	First Owner	23.4 kmpl	1248 CC
1	Diesel	Individual	Manual	Second Owner	21.14 kmpl	1498 CC
2	Petrol	Individual	Manual	Third Owner	17.7 kmpl	1497 CC
3	Diesel	Individual	Manual	First Owner	23.0 kmpl	1396 CC
4	Petrol	Individual	Manual	First Owner	16.1 kmpl	1298 CC
5	Petrol	Individual	Manual	First Owner	20.14 kmpl	1197 CC
6	LPG	Individual	Manual	First Owner	17.3 km/kg	1061 CC
7	Petrol	Individual	Manual	Second Owner	16.1 kmpl	796 CC
8	Diesel	Individual	Manual	First Owner	23.59 kmpl	1364 CC
9	Diesel	Individual	Manual	First Owner	20.0 kmpl	1399 CC

	max_power	torque	seats
0	74 bhp	190Nm@ 2000rpm	5.0
1	103.52 bhp	250Nm@ 1500-2500rpm	5.0
2	78 bhp	12.7@ 2,700(kgm@ rpm)	5.0
3	90 bhp	22.4 kgm at 1750-2750rpm	5.0
4	88.2 bhp	11.5@ 4,500(kgm@ rpm)	5.0
5	81.86 bhp	113.75nm@ 4000rpm	5.0
6	57.5 bhp	7.8@ 4,500(kgm@ rpm)	5.0
7	37 bhp	59Nm@ 2500rpm	4.0
8	67.1 bhp	170Nm@ 1800-2400rpm	5.0
9	68.1 bhp	160Nm@ 2000rpm	5.0

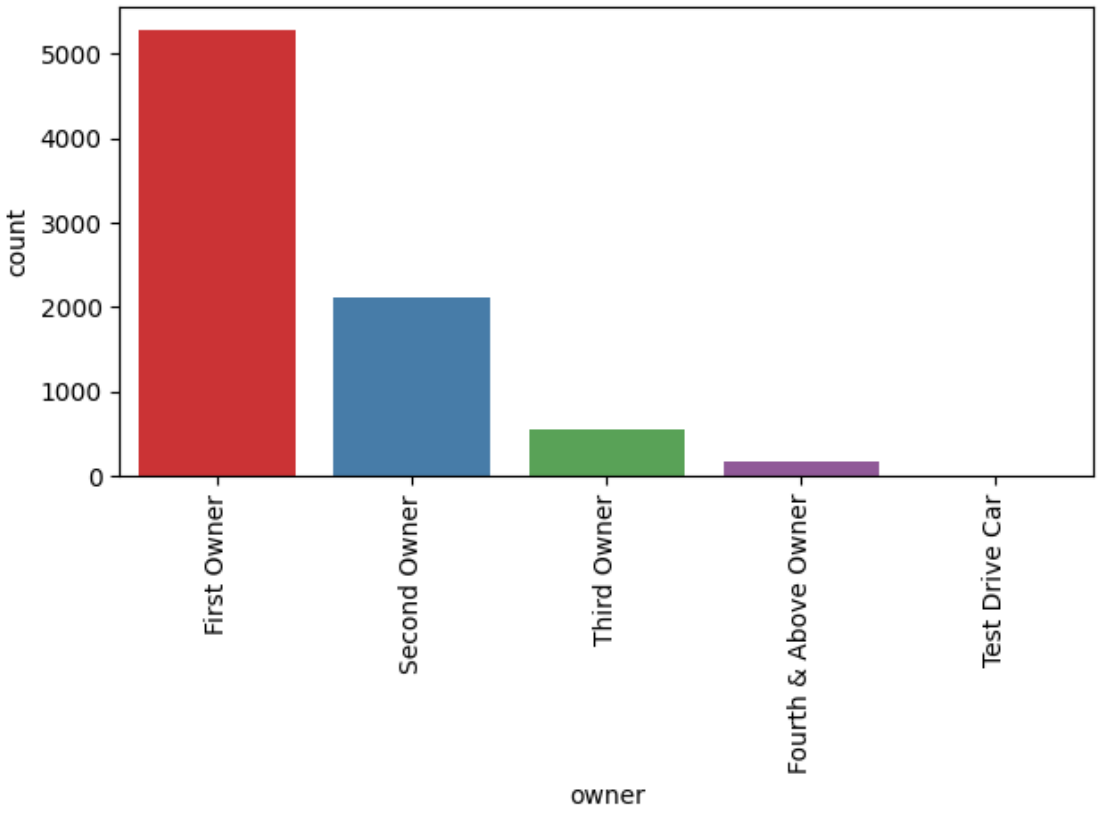
2.1.1 - We will remove torque feature as we don't understand the feature

[ ]:
```
# Remove torque feature
df.drop('torque',axis=1,inplace=True)
```

2.1.2 - We will remove the rows with owner "Test Drive Car" as the price is too high which makes them outliers and this only has 5 rows

[ ]:
```
# Checking counts of owner types
ax = sns.countplot(data = df, x = 'owner',palette= 'Set1')
ax.set_xticklabels(df['owner'].unique(),rotation=90)
plt.tight_layout()
```

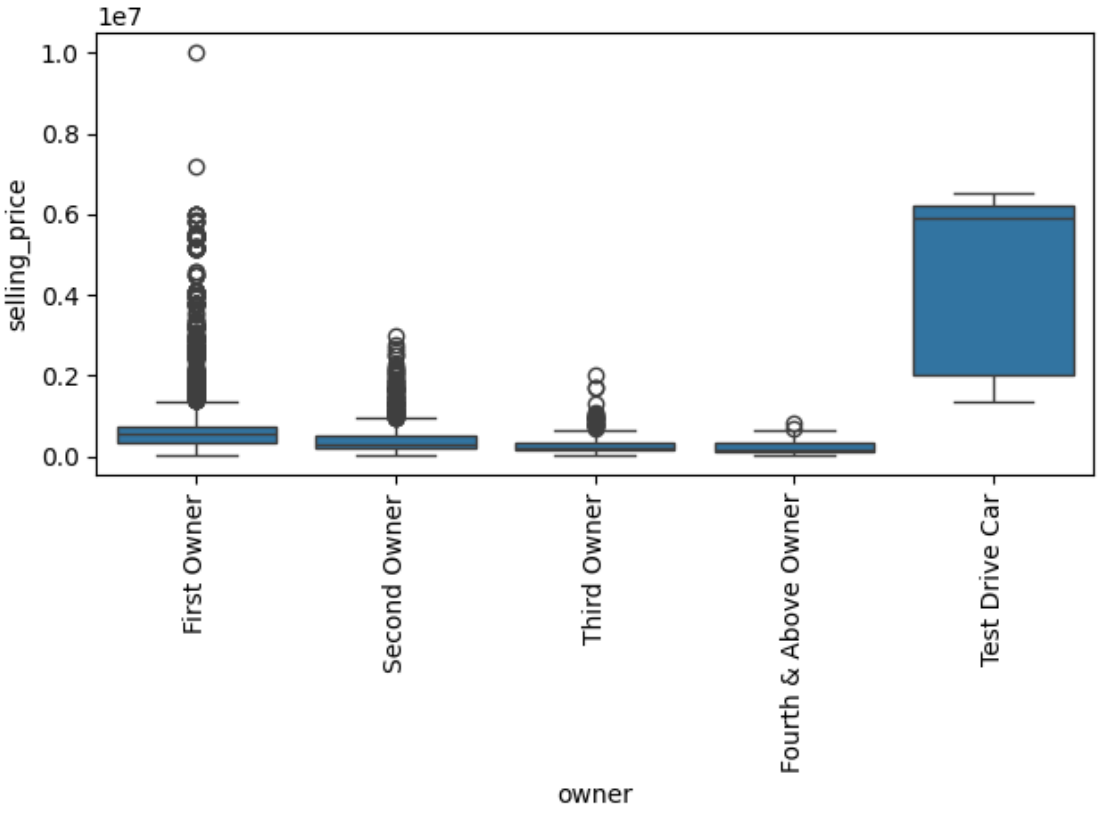
```
plt.show()
```



[ ]:
```
# checking the count of test drive car
df.loc[df['owner'] == 'Test Drive Car','selling_price'].count()
```

[ ]:
```
np.int64(5)
```

[ ]:
```
# checking the distribution of owner types
ax = sns.boxplot(x = df["owner"], y = df["selling_price"])
ax.set_xticklabels(df['owner'].unique(),rotation=90)
plt.tight_layout()
plt.show()
```



[ ]:
```
# Remove rows with "Test Drive Car"
df = df[df['owner'] != 'Test Drive Car']
```

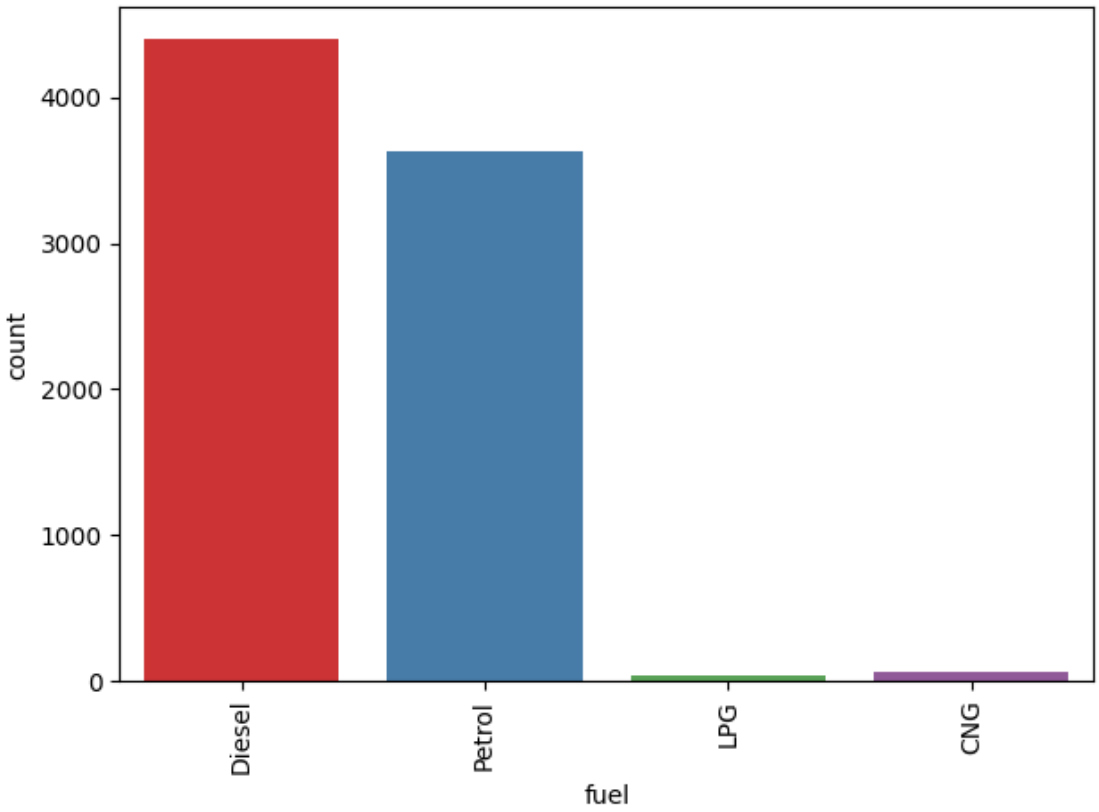
2.1.3 - We will map the owner types to 1 to 4

[ ]:
```
owner = {'First Owner' : 1,
         'Second Owner' : 2,
         'Third Owner' : 3,
         'Fourth & Above Owner' : 4
         }

for k,v in owner.items():
    df.replace(k,v,inplace=True)
```

2.1.4 - We will remove the rows with fuel types “LPG” and “CNG” as they use different mileage units and it has only 38 rows

[ ]:
```
# Checking counts of fuel types
ax = sns.countplot(data = df, x = 'fuel',palette= 'Set1')
ax.set_xticklabels(df['fuel'].unique(),rotation=90)
plt.tight_layout()
```

```
plt.show()
```



[ ]:
```
# Checking fuel milage units
df[df['fuel'].isin(['LPG','CND'])]['mileage'].head()
```

[ ]:
```
6       17.3 km/kg
90      26.2 km/kg
870     26.2 km/kg
1511    26.2 km/kg
1658    17.3 km/kg
Name: mileage, dtype: object
```

[ ]:
```
# Checking the number of fuel types "LPG,CNd"
df[df['fuel'].isin(['LPG','CND'])].shape
```

[ ]:
```
(38, 12)
```

[ ]:
```
# Remove the rows with fuel types "LPG,CNd"
df = df[~df['fuel'].isin(['LPG', 'CNG'])]
df['fuel'].unique()
```

[ ]:
```
array(['Diesel', 'Petrol'], dtype=object)
```

2.1.5 - removing unit 'kmpl' in 'milage' feature and convert it into numerical feature

[ ]:
```
# Replace 'kmpl' with blank
df.loc[df['mileage'].str.split(" ").str[1] == 'kmpl', 'mileage'] = df.
 ↪loc[df['mileage'].str.split(" ").str[1] == 'kmpl', 'mileage'].str.replace("␣
 ↪kmpl", "")
```

[ ]:
```
# Convert mileage feature to float
df['mileage'] = df['mileage'].astype(float)
```

2.1.6 - removing unit 'CC' in 'engine' feature and convert it into numerical feature

[ ]:
```
# Replace 'CC' with blank
df.loc[df['engine'].str.split(" ").str[1] == 'CC', 'engine'] = df.
 ↪loc[df['engine'].str.split(" ").str[1] == 'CC', 'engine'].str.replace(" CC",␣
 ↪"")
```

[ ]:
```
# Convert engine feature to float
df['engine'] = df['engine'].astype(float)
```

2.1.7 - removing unit 'bhp' in 'max_power' feature and convert it into numerical feature

[ ]:
```
# Replace 'bhp' with blank
df.loc[df['max_power'].str.split(" ").str[1] == 'bhp', 'max_power'] = df.
 ↪loc[df['max_power'].str.split(" ").str[1] == 'bhp', 'max_power'].str.
 ↪replace(" bhp", "")
```

[ ]:
```
# Convert max_power feature to float
df['max_power'] = df['max_power'].astype(float)
```

2.1.8 - We will transform the name feature to brand feature by taking the first word of names

[ ]:
```
# rename the column
df.rename(columns = {'name':'brand'}, inplace = True)
```

[ ]:
```
# Taking the first word of name
df['brand'] = df['brand'].str.split(" ").str[0]
```

[ ]:
```
# Checking clean data
df.head()
```

[ ]:

	brand	year	selling_price	km_driven	fuel	seller_type	transmission	\
0	Maruti	2014	450000	145500	Diesel	Individual	Manual	
1	Skoda	2014	370000	120000	Diesel	Individual	Manual	

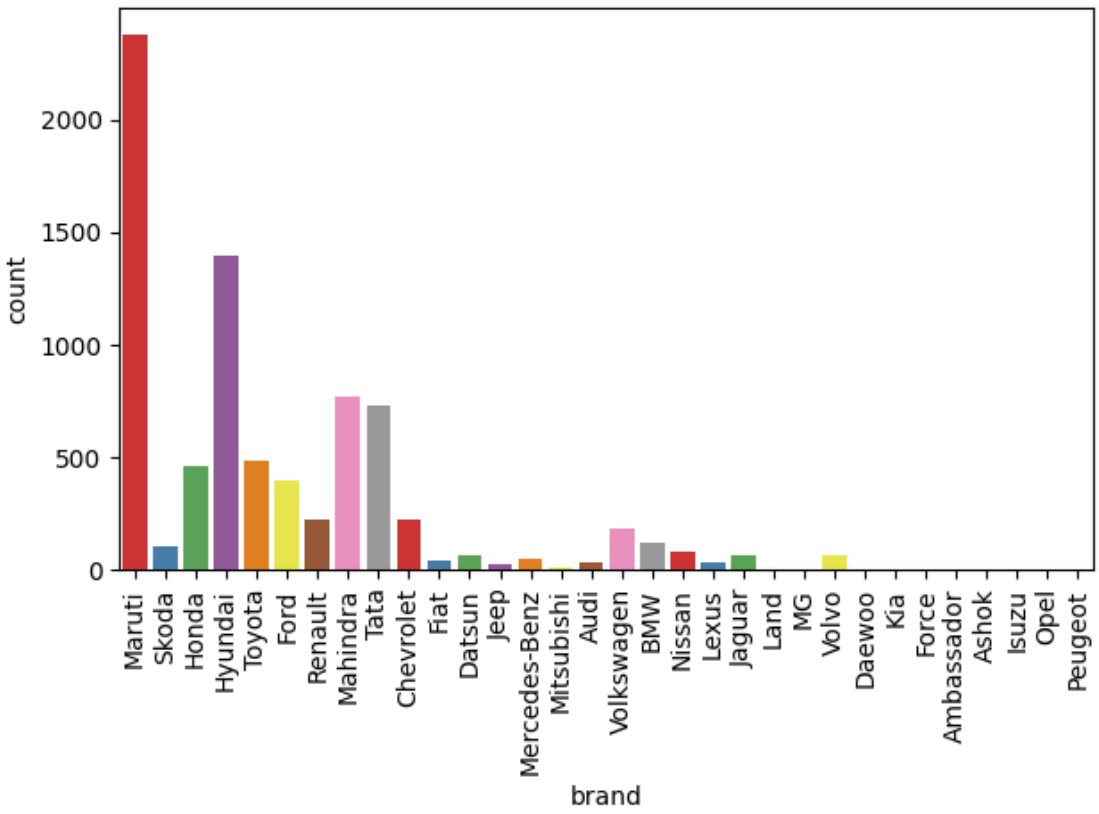
```
2    Honda  2006         158000     140000  Petrol  Individual       Manual
3  Hyundai  2010         225000     127000  Diesel  Individual       Manual
4   Maruti  2007         130000     120000  Petrol  Individual       Manual

   owner  mileage  engine  max_power  seats
0      1    23.40  1248.0      74.00    5.0
1      2    21.14  1498.0     103.52    5.0
2      3    17.70  1497.0      78.00    5.0
3      1    23.00  1396.0      90.00    5.0
4      1    16.10  1298.0      88.20    5.0
```

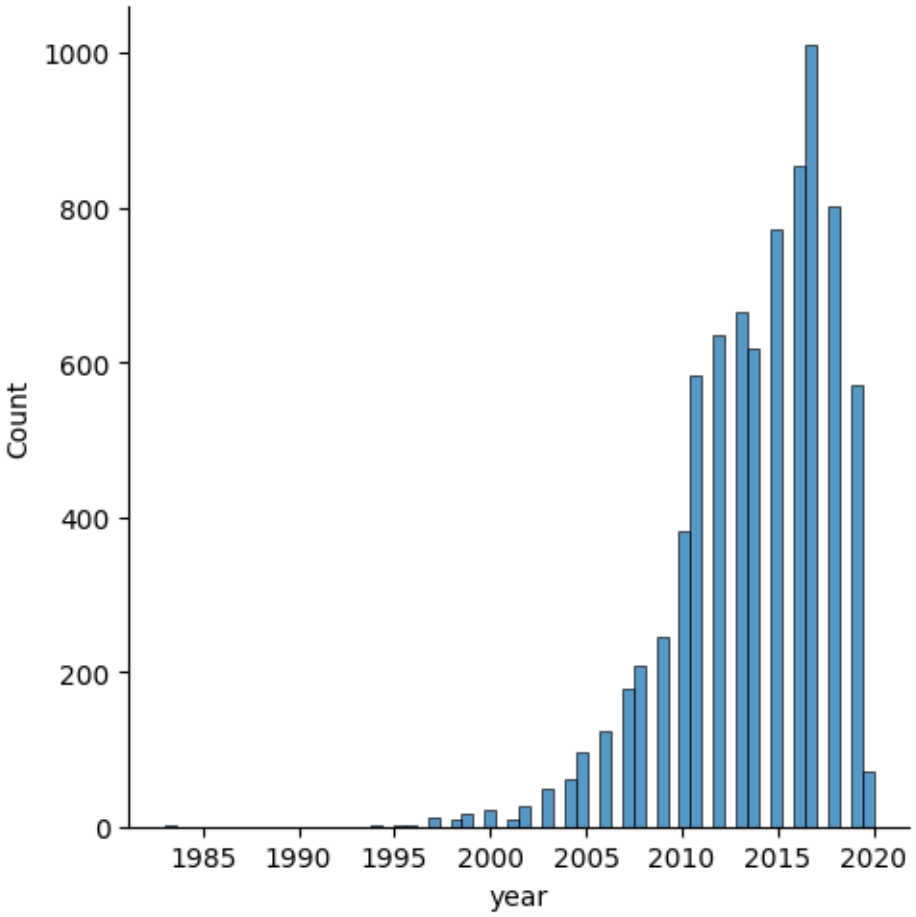
1.3.2 2.2 Univariate analysis

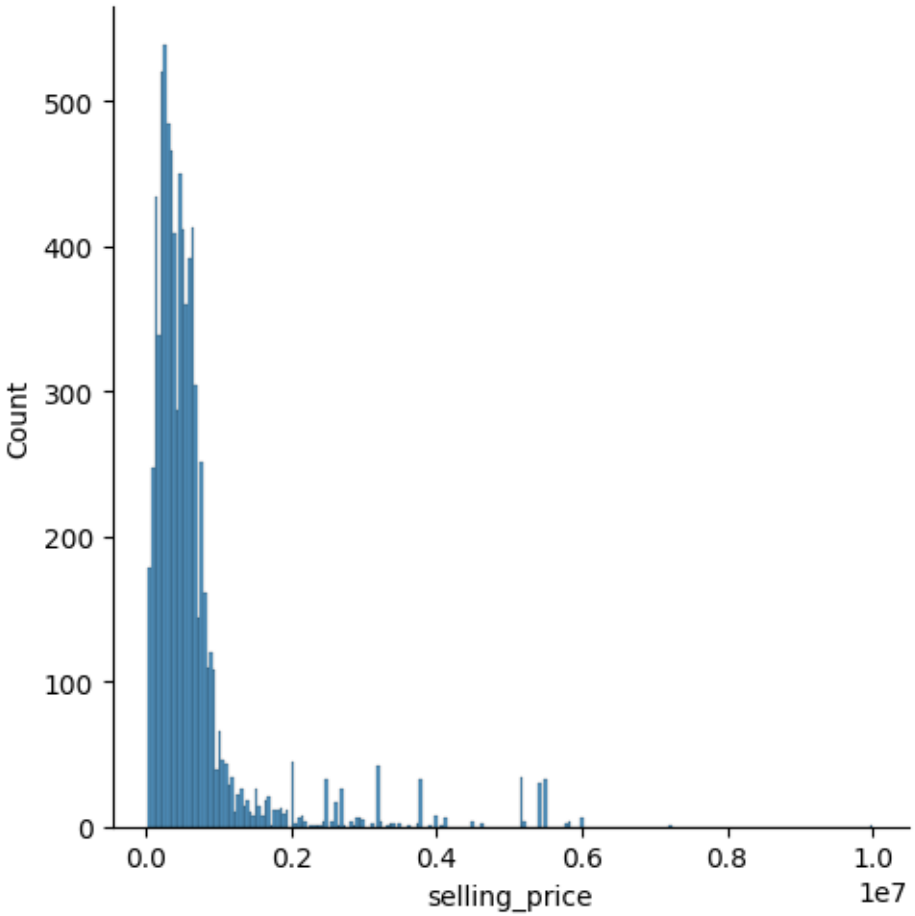
Single variable exploratory data anlaysis

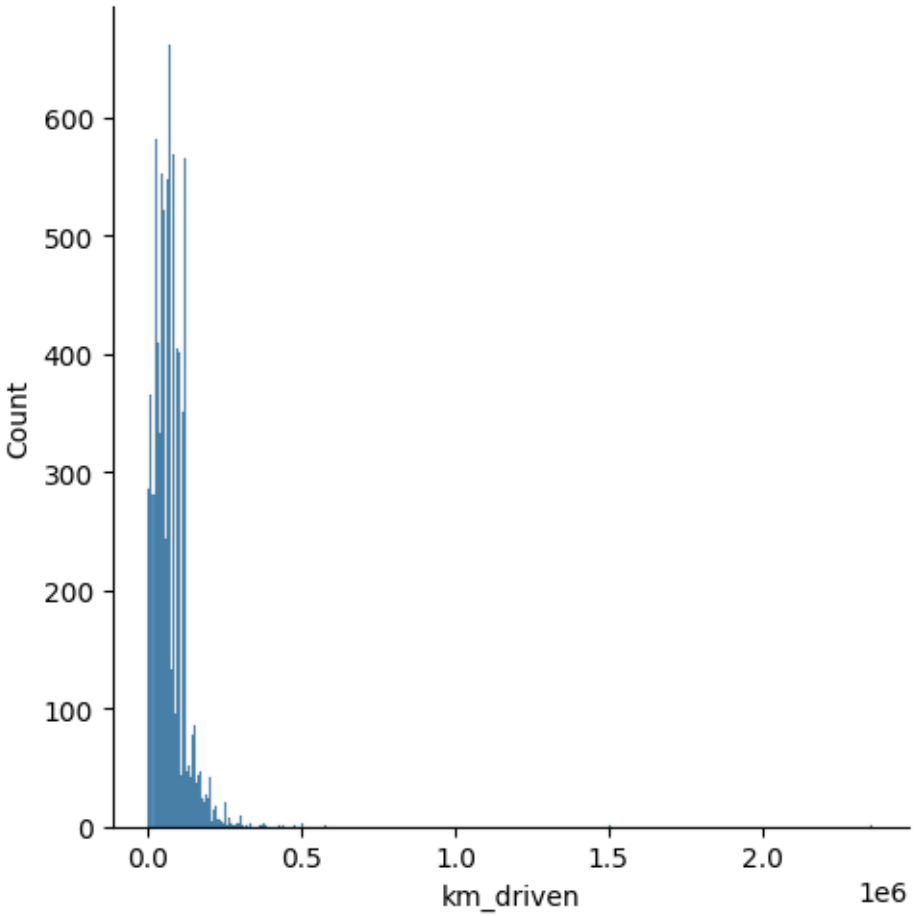
Checking distributions

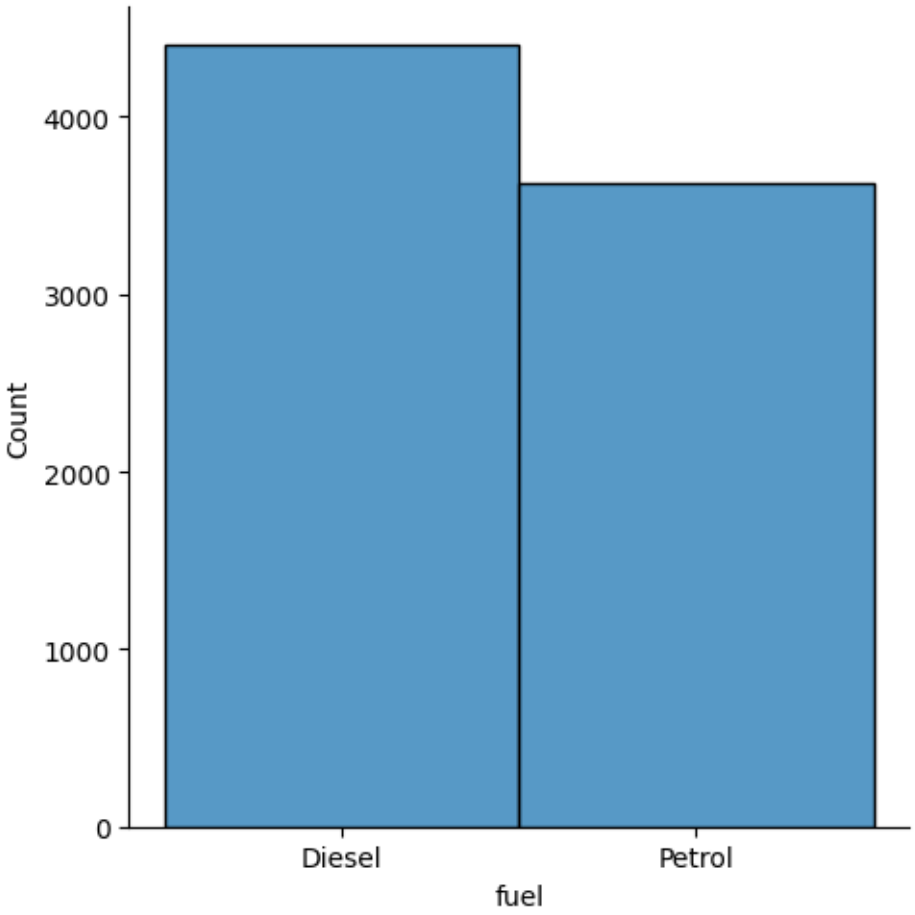
[ ]:
```
for j,i in enumerate(df.columns):
    if i == 'brand':
        ax = sns.countplot(data = df, x = i,palette= 'Set1')
        ax.set_xticklabels(df[i].unique(),rotation=90)
        plt.tight_layout()
        plt.show()
    else:
        sns.displot(data=df,x=df[i])
        plt.show()
```

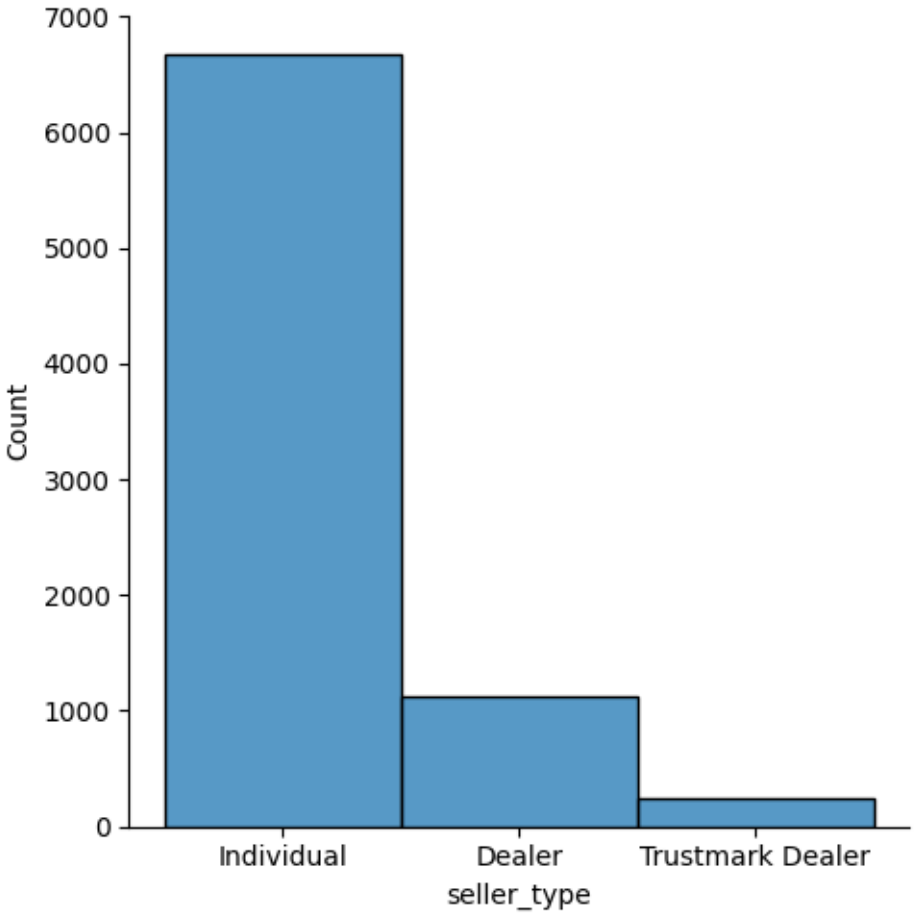

count
2000
1500
1000
500
0
Maruti
Skoda
Honda
Hyundai
Toyota
Ford
Renault
Mahindra
Tata
Chevrolet
Fiat
Datsun
Jeep
Mercedes-Benz
Mitsubishi
Audi
Volkswagen
BMW
Nissan
Lexus
Jaguar
Land
MG
Volvo
Daewoo
Kia
Force
Ambassador
Ashok
Isuzu
Opel
Peugeot
brand

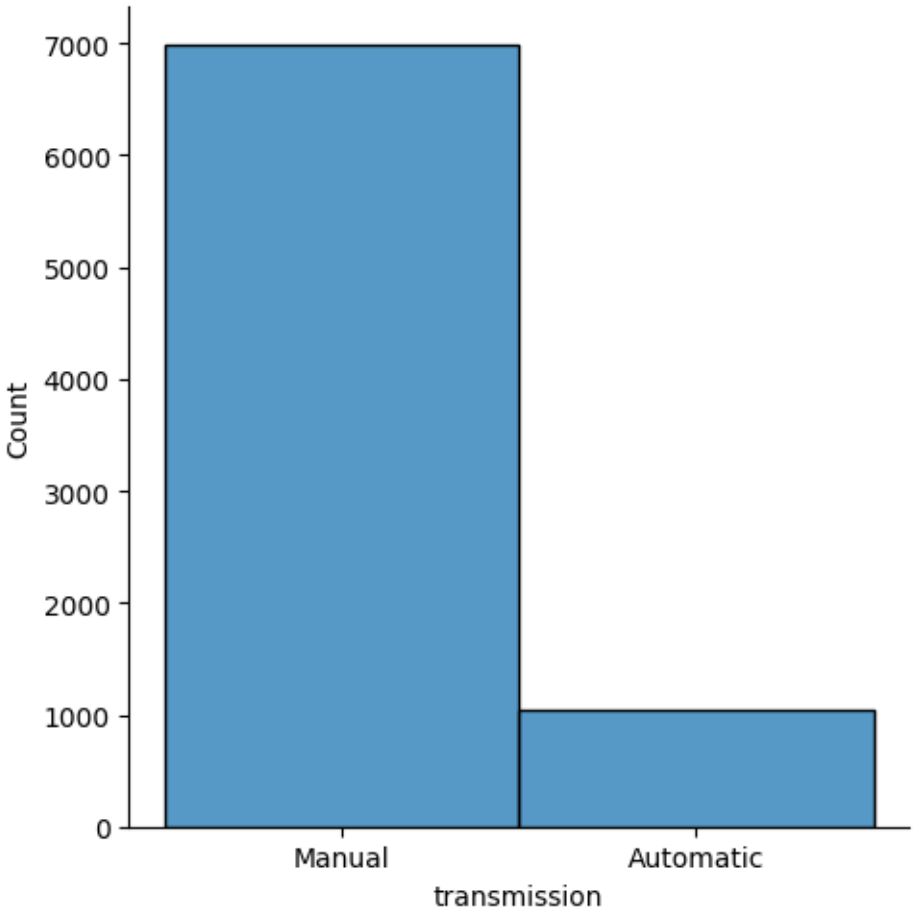

1000
800
600
400
200
0
Count
1985
1990
1995
2000
2005
2010
2015
2020
year

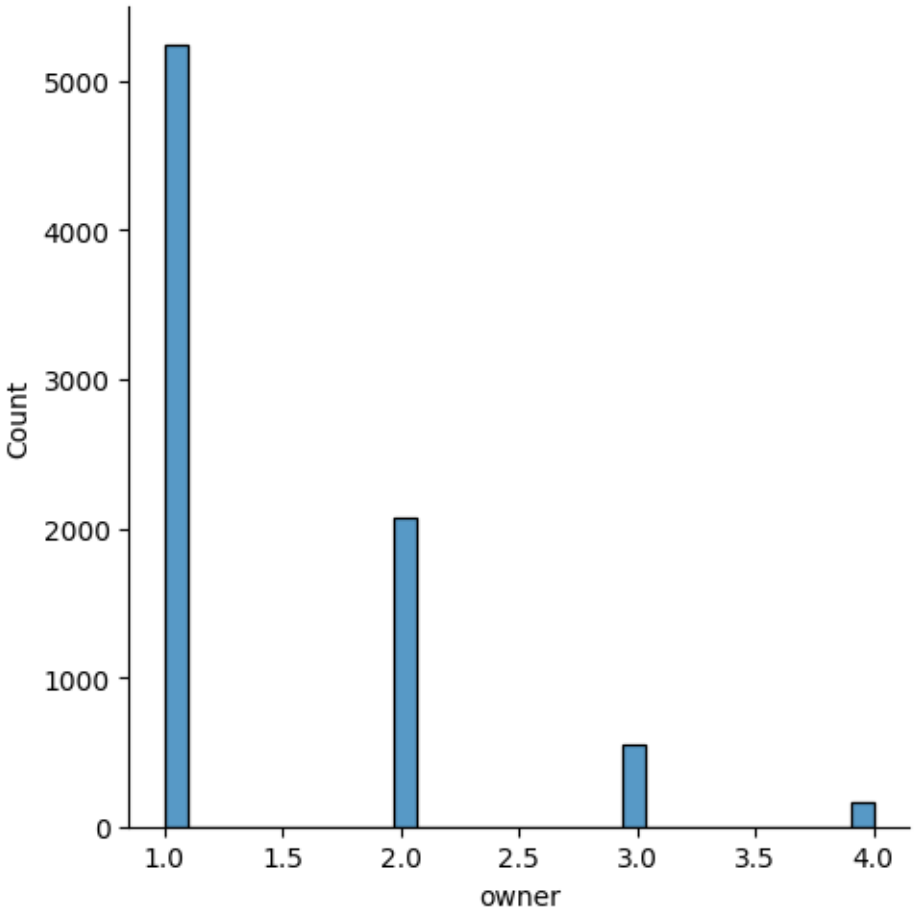

500
400
300
200
100
0
Count
0.0
0.2
0.4
0.6
0.8
1.0
1e7
selling_price

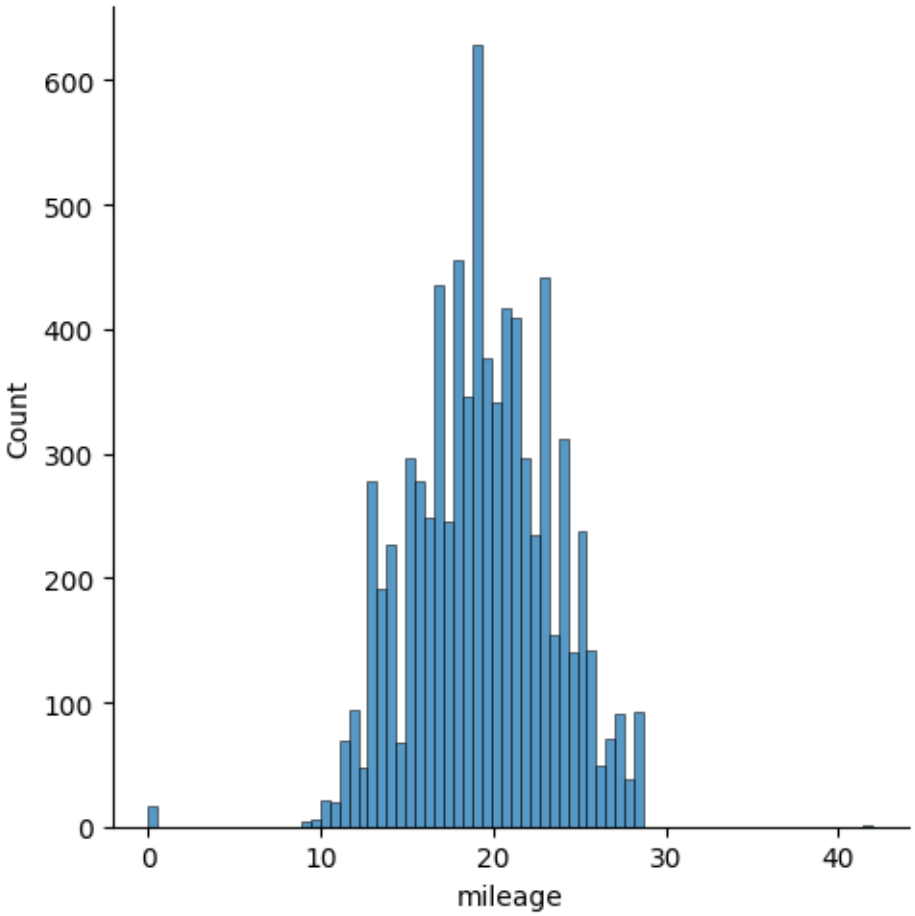

600
500
400
300
200
100
0
Count
0.0
0.5
1.0
1.5
2.0
km_driven
1e6

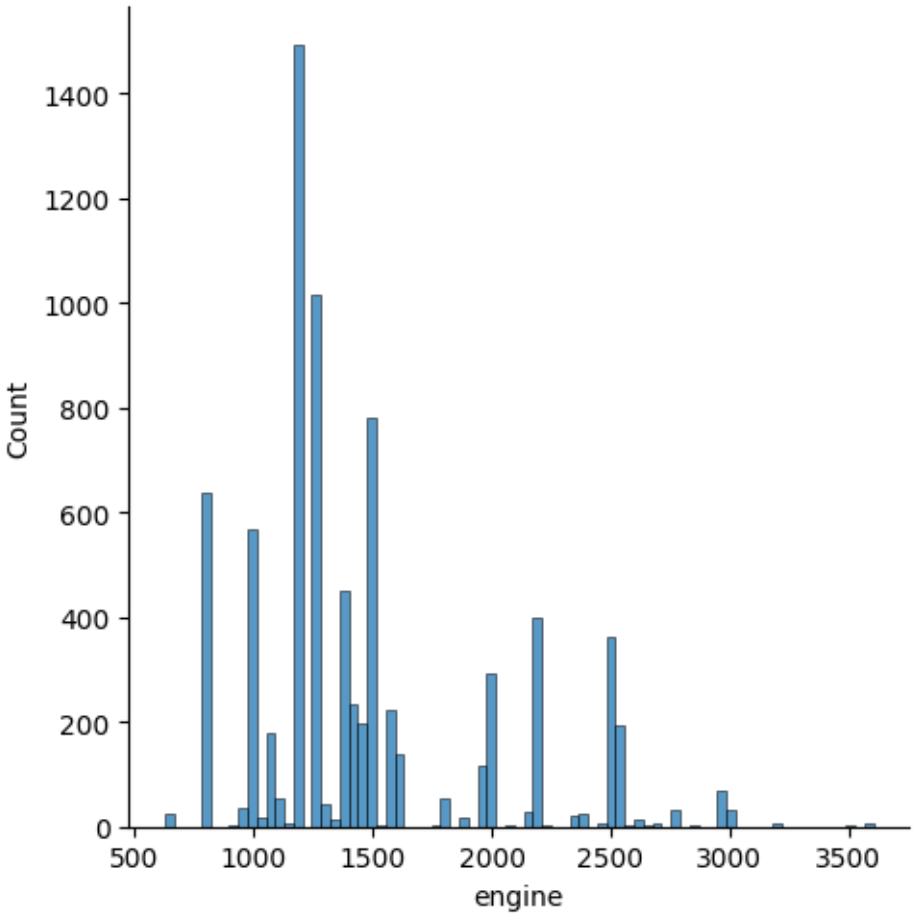

4000
3000
2000
1000
0
Count
Diesel
Petrol
fuel

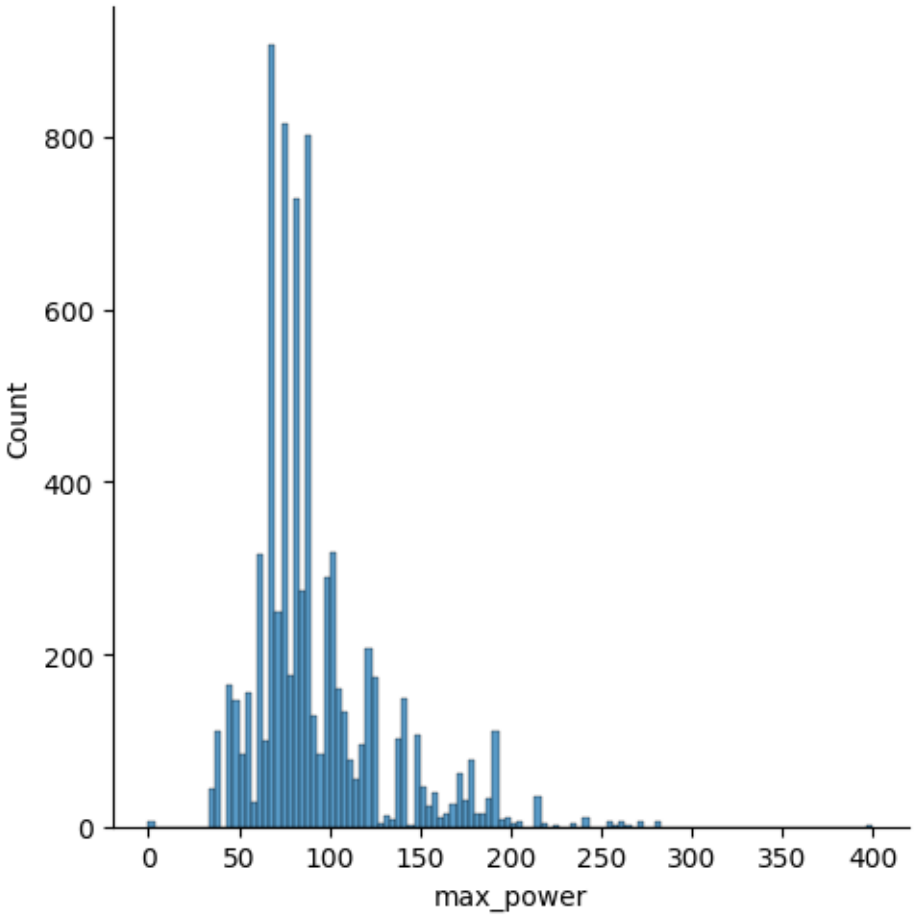

7000
6000
5000
4000
3000
2000
1000
0
Count
Individual
Dealer
Trustmark Dealer
seller_type

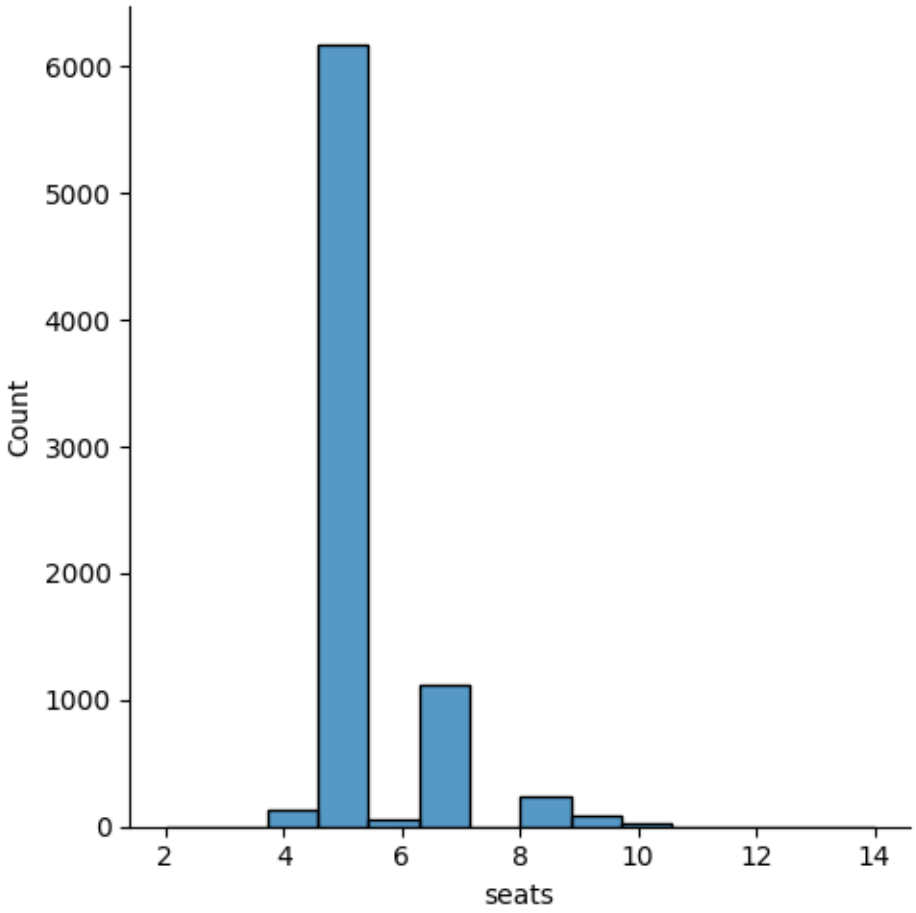

7000
6000
5000
4000
3000
2000
1000
0
Count
Manual
Automatic
transmission


5000
4000
3000
2000
1000
0
Count
1.0
1.5
2.0
2.5
3.0
3.5
4.0
owner


600
500
400
300
200
100
0
Count
0
10
20
30
40
mileage


1400
1200
1000
800
600
400
200
0
Count
500
1000
1500
2000
2500
3000
3500
engine


800
600
400
200
0
Count
0
50
100
150
200
250
300
350
400
max_power



1.3.3 2.3 Multivariate analysis

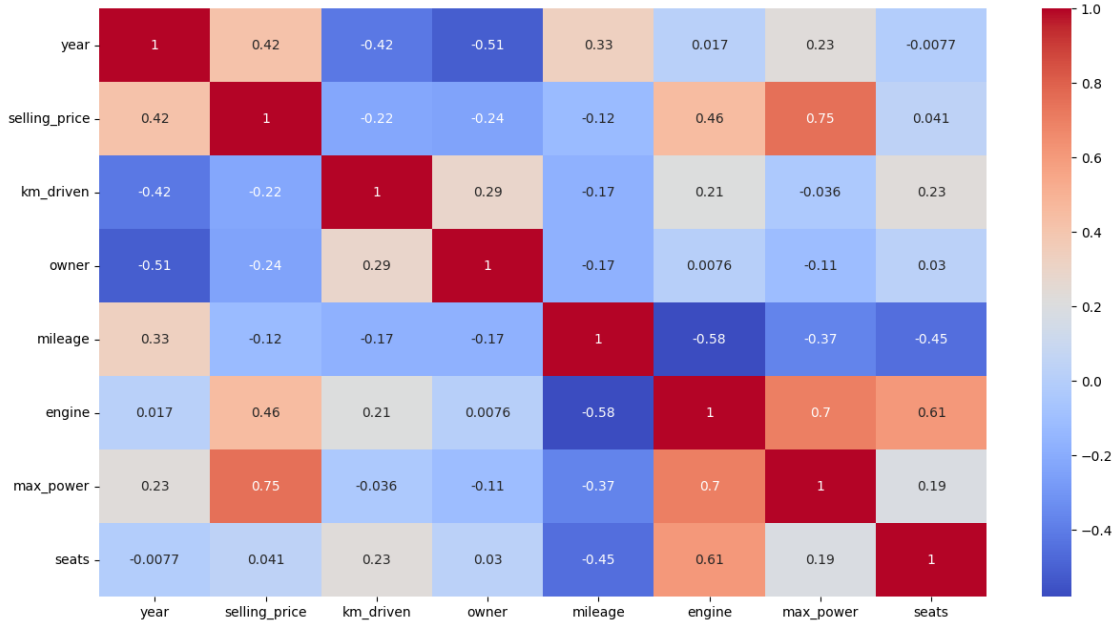
Multiple variable exploratory data analysis

Correlation Matrix Let's use correlation matrix to find strong factors predicting car price. It's also for checking whether certain features are too correlated.

[ ]:
```
df_corr = df[[ 'year', 'selling_price', 'km_driven', 'owner', 'mileage',␣
 ↪'engine', 'max_power', 'seats']]
```

[ ]:
```
# Let's check out heatmap
plt.figure(figsize = (15,8))
sns.heatmap(df_corr.corr(), annot=True, cmap="coolwarm")  #don't forget these␣
 ↪are not all variables! categorical is not here...
```

[ ]: <Axes: >



Label encoding Apply Label encoding to categorical features to see the correlations

[ ]:
```
# check unique values of four categorical features

print(f"brand : {len(df['brand'].unique())}")
print(f"fuel : {len(df['fuel'].unique())}")
print(f"transmission : {len(df['transmission'].unique())}")
print(f"seller_type : {len(df['seller_type'].unique())}")
```

```
brand : 32
fuel : 2
transmission : 2
seller_type : 3
```

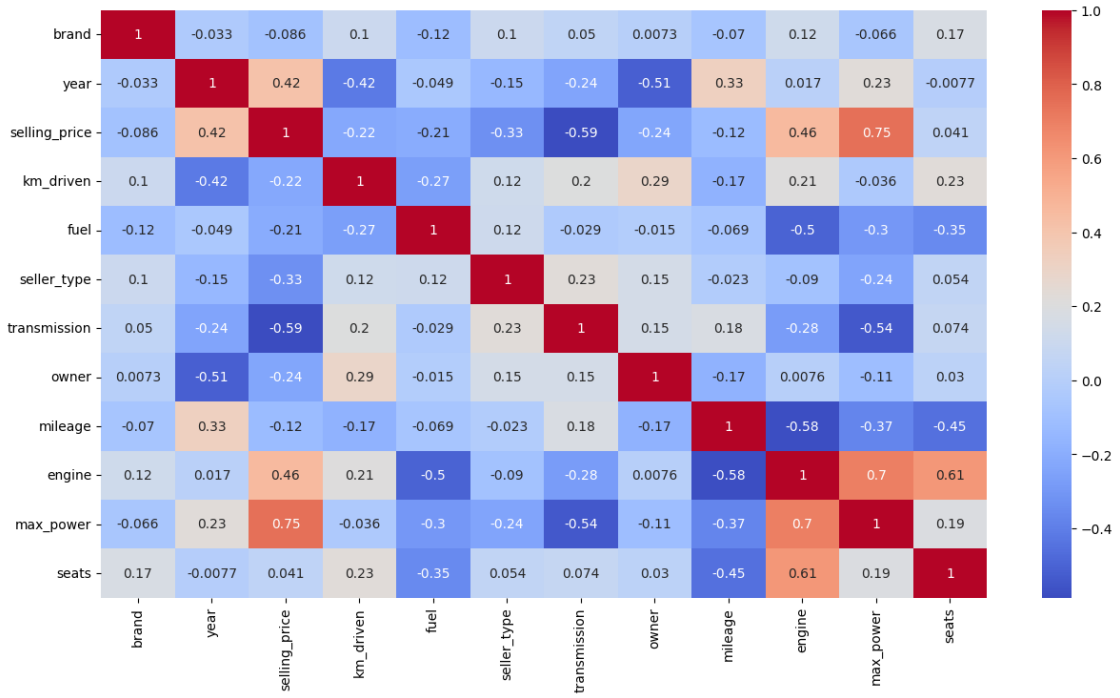
[ ]:
```
# apply label encoding to check corelation
from sklearn.preprocessing import LabelEncoder

le = LabelEncoder()
df["fuel"] = le.fit_transform(df["fuel"])
df["transmission"] = le.fit_transform(df["transmission"])
df["brand"] = le.fit_transform(df["brand"])
df["seller_type"] = le.fit_transform(df["seller_type"])

print(df["fuel"].unique(),df["transmission"].unique())
print(df["brand"].unique(),df["seller_type"].unique())
```

```
[0 1] [1 0]
```

```
[20 27 10 11 29  9 26 19 28  4  7  6 14 21 22  2 30  3 23 17 13 16 18 31
  5 15  8  0  1 12 24 25] [1 0 2]
```

[ ]:
```
# Let's check out heatmap
plt.figure(figsize = (15,8))
sns.heatmap(df.corr(), annot=True, cmap="coolwarm")  #don't forget these are␣
 ↪not all variables! categorical is not here...
```

[ ]:
```
<Axes: >
```

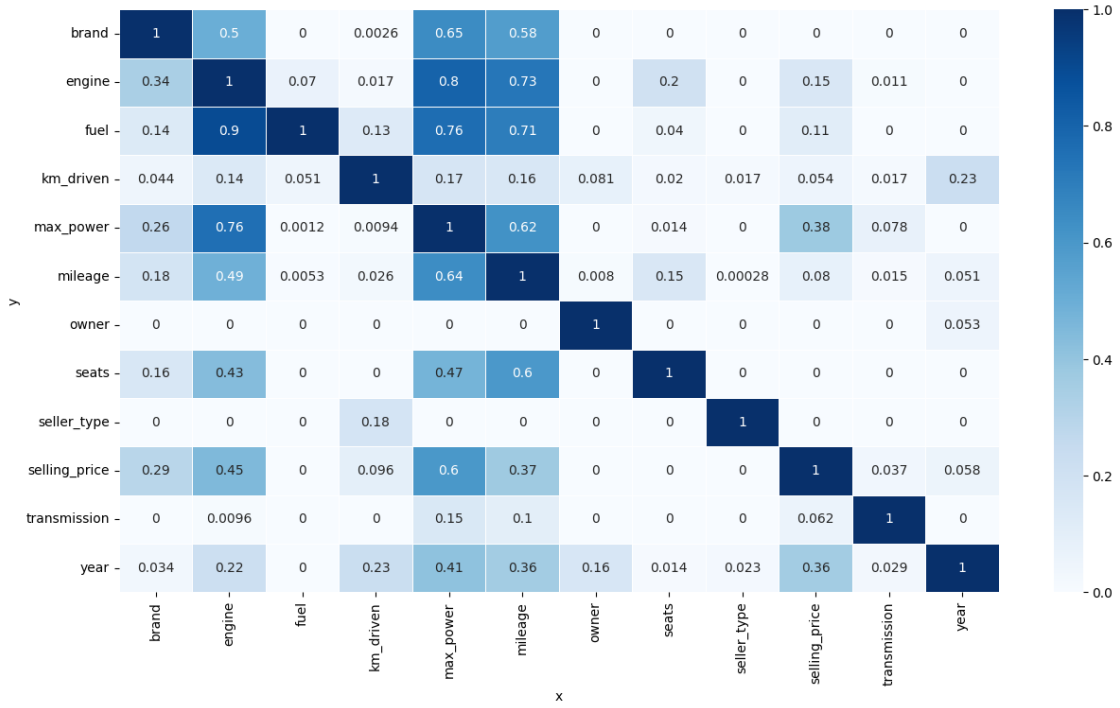


Predictive Power Score

[ ]:
```
import ppscore as pps

# before using pps, let's drop country and year
dfcopy = df.copy()
# dfcopy.drop(['country', 'year'], axis='columns', inplace=True)
# pps.matrix(dfcopy)[['x', 'y', 'ppscore']].pivot()
#this needs some minor preprocessing because seaborn.heatmap unfortunately does␣
 ↪not accept tidy data
matrix_df = pps.matrix(dfcopy)[['x', 'y', 'ppscore']].pivot(columns='x',␣
 ↪index='y', values='ppscore')

#plot
plt.figure(figsize = (15,8))
```

```
sns.heatmap(matrix_df, vmin=0, vmax=1, cmap="Blues", linewidths=0.5, annot=True)
```

[ ]: <Axes: xlabel='x', ylabel='y'>



The brand feature will not be chosen to train model as it does not explain much to selling price. The seller_type has three unique categories. So, this feature will be one-hot encoded.

[ ]:
```
df['seller_type'] = le.inverse_transform(df['seller_type'] )
```

[ ]:
```
df.head()
```

[ ]:

	brand	year	selling_price	km_driven	fuel	seller_type	transmission	\
0	20	2014	450000	145500	0	Individual	1	
1	27	2014	370000	120000	0	Individual	1	
2	10	2006	158000	140000	1	Individual	1	
3	11	2010	225000	127000	0	Individual	1	
4	20	2007	130000	120000	1	Individual	1	

	owner	mileage	engine	max_power	seats
0	1	23.40	1248.0	74.00	5.0
1	2	21.14	1498.0	103.52	5.0
2	3	17.70	1497.0	78.00	5.0
3	1	23.00	1396.0	90.00	5.0

```
4      1    16.10  1298.0      88.20    5.0
```

```
[ ]: df = pd.get_dummies(data=df,columns=['seller_type'],drop_first=True,dtype=int)
```

```
[ ]: df.head()
```

```
[ ]:    brand  year  selling_price  km_driven  fuel  transmission  owner  mileage  \
0     20  2014         450000     145500     0             1      1    23.40
1     27  2014         370000     120000     0             1      2    21.14
2     10  2006         158000     140000     1             1      3    17.70
3     11  2010         225000     127000     0             1      1    23.00
4     20  2007         130000     120000     1             1      1    16.10

   engine  max_power  seats  seller_type_Individual  \
0  1248.0      74.00    5.0                       1
1  1498.0     103.52    5.0                       1
2  1497.0      78.00    5.0                       1
3  1396.0      90.00    5.0                       1
4  1298.0      88.20    5.0                       1

   seller_type_Trustmark Dealer
0                             0
1                             0
2                             0
3                             0
4                             0
```

```
[ ]: # normalizing the feature
df['year'] = df['year'].apply(lambda x : (x - 1886) / (2024-1886) )
```

1.4 3. Feature Engineering

We gonna skip Feature Engineering for now

1.5 4. Feature selection

According to the correlation matrix

- seats and brand have less than 0.2 of correlation scores with selling_price(target). So, these features will be removed.
- max_power and engine are highly correlated with 0.7. But, I will keep them both as high max_power with small engine might explain built quality of car (in terms of power losses due to friction)

According to the predictive power score

- transmission, owner, seller_type and km_driven has less than 0.1 score.
- But, only km_driven will be removed as the others have fair correlation scores with selling_price and also with assumption of they are somewhat important and nuanced features.

[ ]:
```
df.columns
```

[ ]:
```
Index(['brand', 'year', 'selling_price', 'km_driven', 'fuel', 'transmission',
       'owner', 'mileage', 'engine', 'max_power', 'seats',
       'seller_type_Individual', 'seller_type_Trustmark Dealer'],
      dtype='object')
```

[ ]:
```
#x is our strong features
X = df[['year', 'fuel', 'seller_type_Individual', 'seller_type_Trustmark␣
 ↪Dealer',
       'transmission', 'owner', 'engine', 'max_power']]

#y is simply selling price
y = df["selling_price"]
```

[ ]:
```
# check if y has missing values to remove
df["selling_price"].isna().sum()
```

[ ]:
```
np.int64(0)
```

1.5.1 Train test split

[ ]:
```
df.shape
```

[ ]:
```
(8028, 13)
```

[ ]:
```
# I assume only 10 percent of test data will be enough as it is around 800.
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.1,␣
 ↪random_state = 42)
```

1.6 5. Preprocessing

1.6.1 Null values

[ ]:
```
#check for null values
X_train.isna().sum()
```

[ ]:
```
year                            0
fuel                            0
seller_type_Individual          0
seller_type_Trustmark Dealer    0
transmission                    0
owner                           0
engine                        199
max_power                     193
```

```
dtype: int64
```

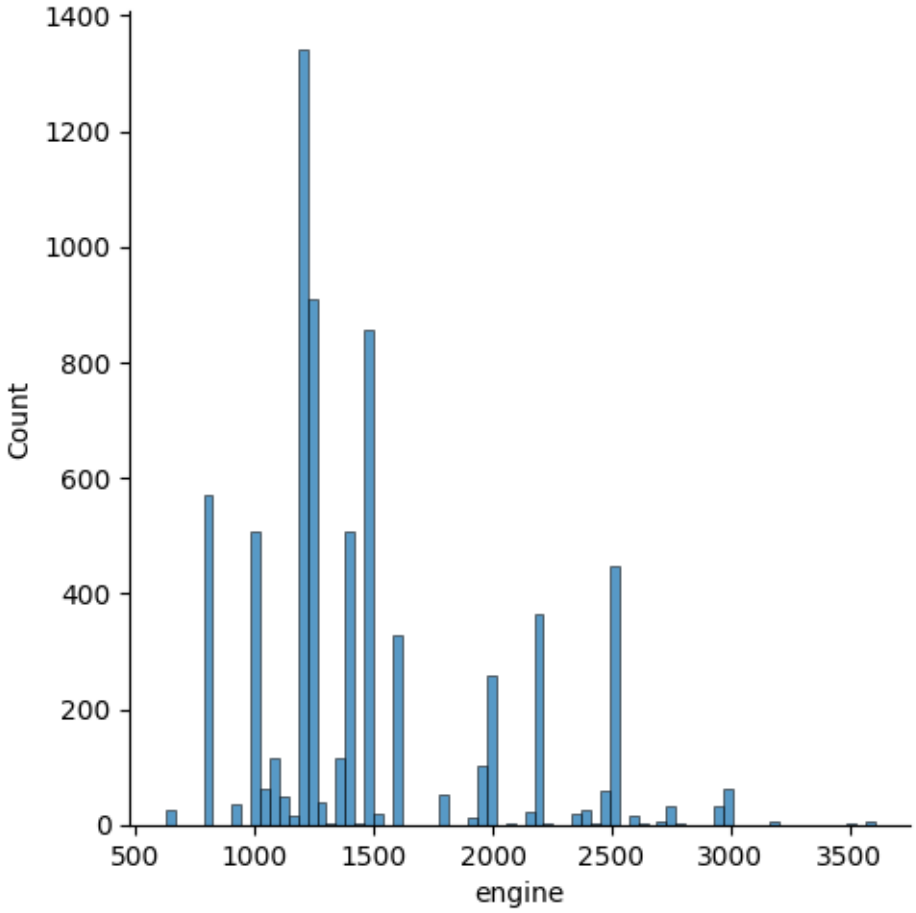
[ ]:
```
X_test.isna().sum()
```

[ ]:
```
year                            0
fuel                            0
seller_type_Individual          0
seller_type_Trustmark Dealer    0
transmission                    0
owner                           0
engine                         15
max_power                      15
dtype: int64
```

As the distributions of engine and max_power has right skewness, median values will be used to replace

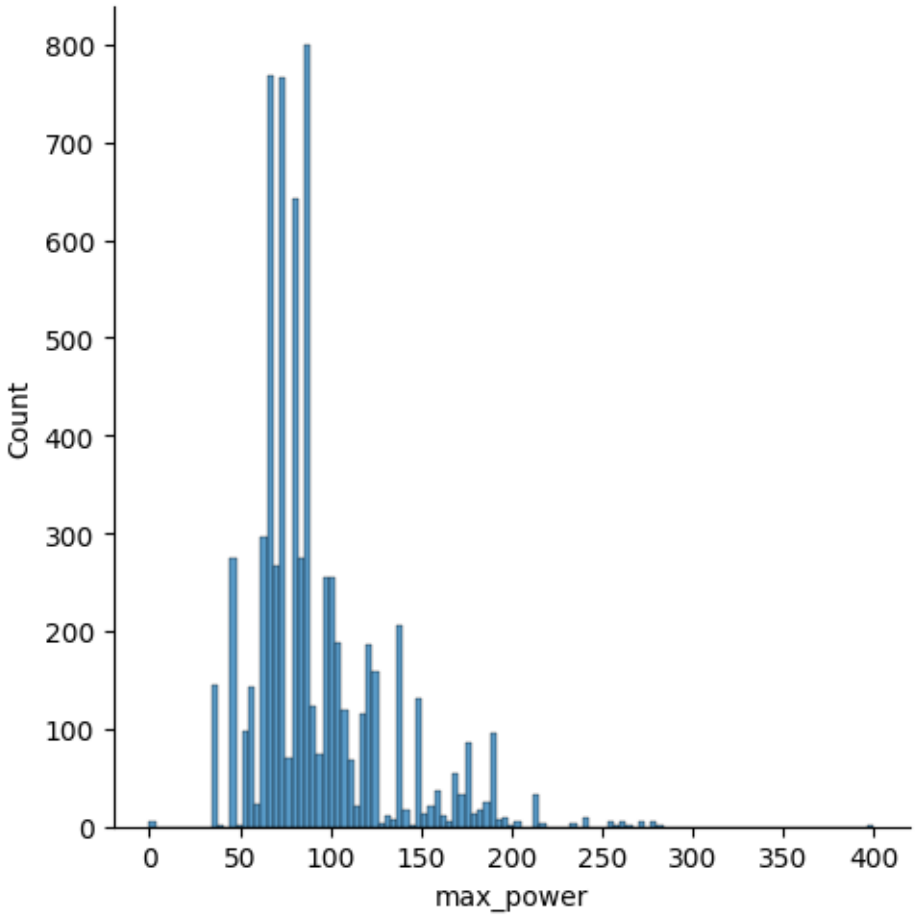
[ ]:
```
sns.displot(data=X_train, x='engine')
```

[ ]:
```
<seaborn.axisgrid.FacetGrid at 0x7f07b677bfa0>
```



[ ]:
```
sns.displot(data=X_train, x='max_power')
```

[ ]: <seaborn.axisgrid.FacetGrid at 0x7f07bb649cf0>



[ ]:
```
#let's fill the testing set with the training distribution first!
# X_test['school'].fillna(X_train['school'].mean(), inplace=True)
X_train['engine'].fillna(X_train['engine'].median(), inplace=True)
X_train['max_power'].fillna(X_train['max_power'].median(), inplace=True)
```

[ ]:
```
#let's fill the testing set with the training distribution first!
# X_test['school'].fillna(X_train['school'].mean(), inplace=True)
X_test['engine'].fillna(X_train['engine'].median(), inplace=True)
X_test['max_power'].fillna(X_train['max_power'].median(), inplace=True)
```

[ ]:
```
#check again
X_train.isna().sum()
```

[ ]:
```
year                            0
fuel                            0
seller_type_Individual          0
seller_type_Trustmark Dealer    0
transmission                    0
owner                           0
engine                          0
max_power                       0
dtype: int64
```

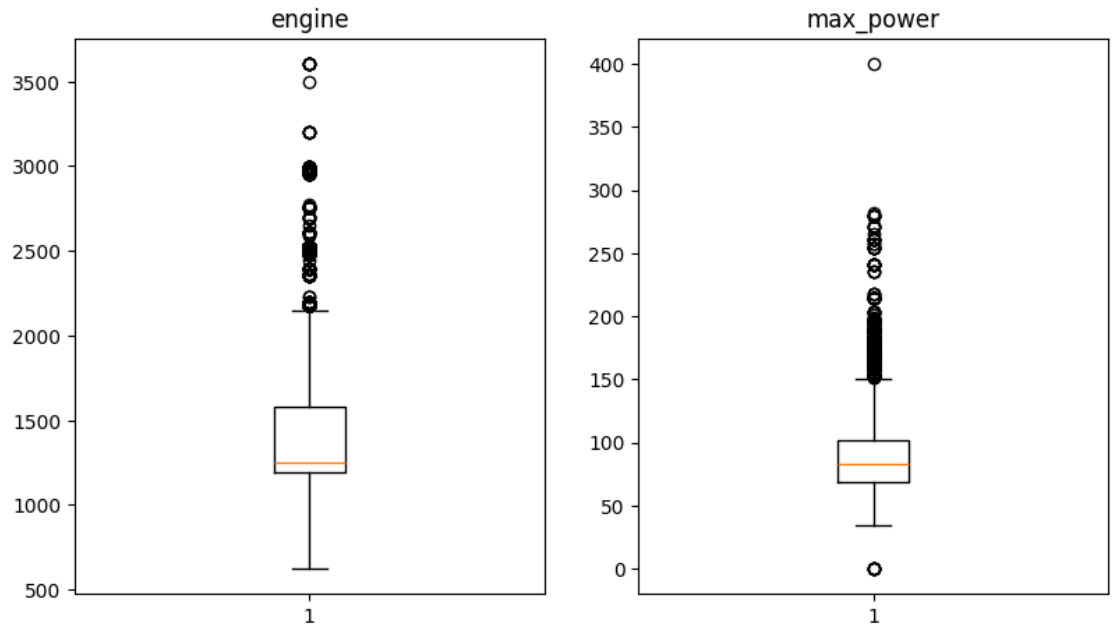
[ ]:
```
X_test.isna().sum()
```

[ ]:
```
year                            0
fuel                            0
seller_type_Individual          0
seller_type_Trustmark Dealer    0
transmission                    0
owner                           0
engine                          0
max_power                       0
dtype: int64
```

1.6.2 Checking Outliers

For two numerical features of engine and max_power, outliers need to be checked for scaling

[ ]:
```
# Create a dictionary of columns.
col_dict = {'engine':1,'max_power':2}

# Detect outliers in each variable using box plots.
plt.figure(figsize=(20,30))

for variable,i in col_dict.items():
                    plt.subplot(5,4,i)
                    plt.boxplot(X_train[variable])
                    plt.title(variable)

plt.show()
```



[ ]:
```
def outlier_count(col, data = X_train):

    # calculate your 25% quatile and 75% quatile
    q75, q25 = np.percentile(data[col], [75, 25])

    # calculate your inter quatile
    iqr = q75 - q25

    # min_val and max_val
    min_val = q25 - (iqr*1.5)
    max_val = q75 + (iqr*1.5)

    # count number of outliers, which are the data that are less than min_val␣
↪or more than max_val calculated above
    outlier_count = len(np.where((data[col] > max_val) | (data[col] <␣
↪min_val))[0])

    # calculate the percentage of the outliers
    outlier_percent = round(outlier_count/len(data[col])*100, 2)

    if(outlier_count > 0):
        print("\n"+15*'-' + col + 15*'-'+"\n")
        print('Number of outliers: {}'.format(outlier_count))
        print('Percent of data that is outlier: {}%'.format(outlier_percent))
```

[ ]:
```
for col in ['engine','max_power']:
    outlier_count(col)
```

```
---------------engine---------------

Number of outliers: 1079
Percent of data that is outlier: 14.93%

---------------max_power---------------

Number of outliers: 519
Percent of data that is outlier: 7.18%
```

1.6.3 Scaling

As the features of engine and max_power has a considerable amount of outliers and skewness and they are not in a bounded range, standardization can be used to scale.

[ ]:
```
from sklearn.preprocessing import StandardScaler

# feature scaling helps improve reach convergence faster
scaler = StandardScaler()
X_train[['engine','max_power']] = scaler.
  ↪fit_transform(X_train[['engine','max_power']])
X_test[['engine','max_power']]  = scaler.
  ↪transform(X_test[['engine','max_power']])
```

For selling_price(y), np.log will be used to scale

[ ]:
```
y_train = y_train.apply(np.log)
y_test = y_test.apply(np.log)
```

[ ]:
```
# Let's check shapes of all X_train, X_test, y_train, y_test
print("Shape of X_train: ", X_train.shape)
print("Shape of X_test: ", X_test.shape)
print("Shape of y_train: ", y_train.shape)
print("Shape of y_test: ", y_test.shape)
```

```
Shape of X_train:  (7225, 8)
Shape of X_test:  (803, 8)
Shape of y_train:  (7225,)
Shape of y_test:  (803,)
```

2 6. Modeling

Modifying the Linear Regression class - allow to 2 degree polynomials - update weights with momentum - add Xavier weight initialization - add r2_score function - add plot_feature_importance

function

```
[ ]: from sklearn.model_selection import KFold
from sklearn.preprocessing import PolynomialFeatures

class LinearRegression(object):

    #in this class, we add cross validation as well for some spicy code....
    kfold = KFold(n_splits=5)

    def __init__(self, regularization, lr=0.001, method='batch',␣
 ↪momentum=0,initialize='xavier',
                 num_epochs=500, batch_size=50, cv=kfold,polynomial=True):
        self.lr          = lr
        self.num_epochs = num_epochs
        self.batch_size = batch_size
        self.method      = method
        self.cv          = cv
        self.regularization = regularization
        self.momentum = momentum
        self.initialize = initialize
        self.grad = 0
        self.polynomial = False
        self.degree = 2
        self.features = None
        self.poly_graph = None
        self.infer = True


    def mse(self, ytrue, ypred): # modify this function to set m = 1 for sto
        if self.method == 'sto':
            m = 1
        else:
            m = ytrue.shape[0]
        return ((ypred - ytrue) ** 2).sum() / m

    def fit(self, X_train, y_train):

        #create a list of kfold scores
        self.kfold_scores_mse = list()
        self.kfold_scores_r2 = list()

        #reset val loss
        self.val_loss_old = np.inf

        # if poynomial is true, transform feature
        if self.polynomial == True:
```

```
            X_train,self.features,self.poly_graph = self._poly(X_train)
            regg = "Polynomial"
        else:
            self.features = X_train.columns
            intercept = np.ones((X_train.shape[0], 1))
            X_train   = np.concatenate((intercept, X_train), axis=1)
            regg = "Linear"

        y_train = y_train.to_numpy()

        #kfold.split in the sklearn.....
        #5 splits
        for fold, (train_idx, val_idx) in enumerate(self.cv.split(X_train)):
            self.grad = 0
            X_cross_train = X_train[train_idx]
            y_cross_train = y_train[train_idx]
            X_cross_val   = X_train[val_idx]
            y_cross_val   = y_train[val_idx]

            # Initialize weights as per self.initialize
            if self.initialize == 'zeros':
                self.theta = np.zeros(X_cross_train.shape[1])
            if self.initialize == 'xavier':
                # number of samples
                m,n = X_cross_train.shape
                # range of weights
                upper, lower = -(1.0/np.sqrt(m)), (1.0/np.sqrt(m))
                # get random numbers
                numbers = np.random.rand(n)
                scaled = lower + numbers * (upper-lower)
                self.theta = scaled
                self.theta[0] = 0
                # print(self.theta)

            #define X_cross_train as only a subset of the data
            #how big is this subset?  => mini-batch size ==> 50

            #one epoch will exhaust the WHOLE training set
            with mlflow.start_run(run_name=f"Fold-{fold}", nested=True):

                params = {"method": self.method, "lr": self.lr, "reg":␣
↪type(self).__name__ + f"_{regg}",
                          "momentum" : self.momentum , "initialize_weights" :␣
↪self.initialize
                          }
                mlflow.log_params(params=params)
```

```
                for epoch in range(self.num_epochs):

                    #with replacement or no replacement
                    #with replacement means just randomize
                    #with no replacement means 0:50, 51:100, 101:150, ......300:
↪323
                    #shuffle your index
                    perm = np.random.permutation(X_cross_train.shape[0])

                    X_cross_train = X_cross_train[perm]
                    y_cross_train = y_cross_train[perm]

                    if self.method == 'sto':
                        for batch_idx in range(X_cross_train.shape[0]):
                            X_method_train = X_cross_train[batch_idx].
↪reshape(1, -1) #(11,) ==> (1, 11) ==> (m, n)
                            y_method_train = y_cross_train[batch_idx]
                            train_loss = self._train(X_method_train,␣
↪y_method_train)
                    elif self.method == 'mini':
                        for batch_idx in range(0, X_cross_train.shape[0], self.
↪batch_size):
                            #batch_idx = 0, 50, 100, 150
                            X_method_train = X_cross_train[batch_idx:
↪batch_idx+self.batch_size, :]
                            y_method_train = y_cross_train[batch_idx:
↪batch_idx+self.batch_size]
                            train_loss = self._train(X_method_train,␣
↪y_method_train)
                    else:
                        X_method_train = X_cross_train
                        y_method_train = y_cross_train
                        train_loss = self._train(X_method_train, y_method_train)
                        # print(self.theta)
                        # print(self.grad)
                        # print(train_loss)

                    mlflow.log_metric(key="train_loss", value=train_loss,␣
↪step=epoch)

                    # Added r2 to compare the performance
                    self.infer = False
                    yhat_val = self.predict(X_cross_val)
                    self.infer = True
                    val_loss_new = self.mse(y_cross_val, yhat_val)
                    r2_score = self.r2_score(y_cross_val, yhat_val)
```

```
                    mlflow.log_metric(key="val_loss", value=val_loss_new,␣
↪step=epoch)
                    mlflow.log_metric(key="Val_R2", value=r2_score, step=epoch)

                    # self.val_mse.append(round(val_loss_new,2))
                    # self.val_r2.append(round(r2_score,2))
                    #early stopping
                    if np.allclose(val_loss_new, self.val_loss_old):
                        break
                    self.val_loss_old = val_loss_new

                self.kfold_scores_mse.append(round(val_loss_new,2))
                self.kfold_scores_r2.append(round(r2_score,2))
                print(f"Fold {fold}: {val_loss_new}")


    def _train(self, X, y):
        self.infer = False
        yhat = self.predict(X)
        m    = X.shape[0]
        grad = (1/m) * X.T @(yhat - y) + self.regularization.derivation(self.
↪theta)
        # use update function to update grad with momentum
        self.theta = self._update(grad)
        # self.theta = self.theta - self.lr * grad
        self.infer = True
        return self.mse(y, yhat)

    def predict(self, X):
        if self.infer == True:
            if self.polynomial == True:
                X = self.poly_graph.transform(X)
            else:
                intercept = np.ones((X_train.shape[0], 1))
                X   = np.concatenate((intercept, X), axis=1)
        return X @ self.theta  #===>(m, n) @ (n, )

    def _coef(self):
        return self.theta[1:]  #remind that theta is (w0, w1, w2, w3, w4.....wn)
                               #w0 is the bias or the intercept
                               #w1....wn are the weights / coefficients / theta
    def _bias(self):
        return self.theta[0]

    # r2 function
    def r2_score(self, ytrue, ypred):
```

```
        return 1 - (((ytrue - ytrue.mean()) ** 2).sum() / ((ytrue - ypred) **␣
↪2).sum())

    # update the gradients with momentum
    def _update(self,grad):
        step = self.lr * grad
        # print(self.lr * grad)
        prev_step =  self.lr * self.grad
        self.grad = grad
        return self.theta - step + self.momentum * prev_step

    # Plot feature importance
    def plot_feature_importance(self):
        coef_matrix = self._coef()
        sorted_idx=coef_matrix.argsort()
        plt.barh(self.features[1:][sorted_idx], coef_matrix[sorted_idx])
        plt.xlabel("Feature Importance")
        plt.show()

    def _poly(self,X):
        poly = PolynomialFeatures(self.degree)
        X_transform = poly.fit_transform(X)
        features = poly.get_feature_names_out()
        return X_transform,features,poly
```

[ ]:
```
class LassoPenalty:

    def __init__(self, l):
        self.l = l # lambda value

    def __call__(self, theta): #__call__ allows us to call class as method
        return self.l * np.sum(np.abs(theta))

    def derivation(self, theta):
        return self.l * np.sign(theta)
# Added no penalty class
class NoPenalty:

    def __init__(self, l):
        self.l = 0 # lambda value

    def __call__(self, theta): #__call__ allows us to call class as method
        return 0

    def derivation(self, theta):
        return 0
```

```
class RidgePenalty:

    def __init__(self, l):
        self.l = l

    def __call__(self, theta): #__call__ allows us to call class as method
        return self.l * np.sum(np.square(theta))

    def derivation(self, theta):
        return self.l * 2 * theta

class ElasticPenalty:

    def __init__(self, l = 0.1, l_ratio = 0.5):
        self.l = l
        self.l_ratio = l_ratio

    def __call__(self, theta):  #__call__ allows us to call class as method
        l1_contribution = self.l_ratio * self.l * np.sum(np.abs(theta))
        l2_contribution = (1 - self.l_ratio) * self.l * 0.5 * np.sum(np.
 ↪square(theta))
        return (l1_contribution + l2_contribution)

    def derivation(self, theta):
        l1_derivation = self.l * self.l_ratio * np.sign(theta)
        l2_derivation = self.l * (1 - self.l_ratio) * theta
        return (l1_derivation + l2_derivation)

class Lasso(LinearRegression):

    def __init__(self, method, lr,momentum,initialize,l):
        self.regularization = LassoPenalty(l)
        super().__init__(self.regularization, lr, method,momentum,initialize)

class Ridge(LinearRegression):

    def __init__(self, method, lr,momentum,initialize,l):
        self.regularization = RidgePenalty(l)
        super().__init__(self.regularization, lr, method,momentum,initialize)

class ElasticNet(LinearRegression):

    def __init__(self, method, lr,momentum,initialize,l,l_ratio=0.5):
        self.regularization = ElasticPenalty(l, l_ratio)
        super().__init__(self.regularization, lr, method,momentum,initialize)

# Normal Linear Regression without regularization
```

```
class Normal(LinearRegression):

    def __init__(self, method, lr,momentum,initialize,l):
        self.regularization = NoPenalty(l)
        super().__init__(self.regularization, lr, method,momentum,initialize)
```

2.0.1 6.1 Experiment

To perform experiments, the following functions are defined for convenience

[ ]:
```
#helper function for looping classnames
import sys

def str_to_class(classname):
    return getattr(sys.modules[__name__], classname)

str_to_class("Ridge")
```

[ ]:
```
__main__.Ridge
```

[ ]:
```
# generating all possible experiments
polyno = [True,False]
regs = ["Ridge", "Lasso", "ElasticNet","Normal"]
method = ['batch','mini','sto']
lr = [0.01,0.001,0.0001]
initi = ['zeros','xavier']
mmt = [0,0.4,0.7,0.99]
experiments = pd.DataFrame(list(itertools.
 ↪product(regs,polyno,method,mmt,initi,lr)),
                           ␣
 ↪columns=['Regression','Polynomial','GD_methods','Momentum_Term','Weight_Initialization','Le
experiments.head()
```

[ ]:
```
  Regression  Polynomial GD_methods  Momentum_Term Weight_Initialization  \
0      Ridge        True      batch            0.0                  zeros
1      Ridge        True      batch            0.0                  zeros
2      Ridge        True      batch            0.0                  zeros
3      Ridge        True      batch            0.0                 xavier
4      Ridge        True      batch            0.0                 xavier

   Learning_Rates
0          0.0100
1          0.0010
2          0.0001
3          0.0100
4          0.0010
```

```
[ ]: # experiment helper function, this function facilitate to test on specific␣
      ↪parameters by setting others the same

     def␣
      ↪experiment(experiments,test_on,regs='Ridge',polyno=False,method='batch',lr=0.
      ↪01,initi='xavier',mmt=0.99):
         # query = f"Regression == '{regs}' & Polynomial == {polyno} & GD_methods ==␣
      ↪'{method}' & Learning_Rates == {lr} & Weight_Initialization == '{initi}'  &␣
      ↪Momentum_Term == {mmt} "
         if test_on == 'regs':
             query = f"GD_methods == '{method}' & Learning_Rates == {lr} &␣
      ↪Weight_Initialization == '{initi}'  & Momentum_Term == {mmt} "
         elif test_on == 'method':
             query = f"Regression == '{regs}' & Polynomial == {polyno} &␣
      ↪Learning_Rates == {lr} & Weight_Initialization == '{initi}'  & Momentum_Term␣
      ↪== {mmt} "
         elif test_on == 'lr':
             query = f"Regression == '{regs}' & Polynomial == {polyno} & GD_methods␣
      ↪== '{method}' & Weight_Initialization == '{initi}'  & Momentum_Term == {mmt}␣
      ↪"
         elif test_on == 'initi':
             query = f"Regression == '{regs}' & Polynomial == {polyno} & GD_methods␣
      ↪== '{method}' & Learning_Rates == {lr} & Momentum_Term == {mmt} "
         elif test_on == 'mmt':
             query = f"Regression == '{regs}' & Polynomial == {polyno} & GD_methods␣
      ↪== '{method}' & Learning_Rates == {lr} & Weight_Initialization == '{initi}' "
         else:
             query = "All"
         # display(experiments.query(query))
         if query != "All":
             selected_exps = experiments.query(query)
         else:
             selected_exps = experiments

         val_mse = []
         val_r2 = []
         for index, row in selected_exps.iterrows():
             reg=row['Regression']
             pol=row['Polynomial']
             method=row['GD_methods']
             lr=row['Learning_Rates']
             mmt=row['Momentum_Term']
             initi=row['Weight_Initialization']

             if pol == True:
                 reg_name = f"Polynomial_{reg}"
```

```
        if pol == False:
            reg_name = f"Linear_{reg}"
        params = {"method": method,
                  "lr": lr,
                  "momentum" : mmt ,
                  'initialize' : initi,
                  "l": 0.1}
        exp_name =␣
↪f"reg-{reg_name}-method-{params['method']}-lr-{params['lr']}-momentum-{params['momentum']}-
        mlflow.start_run(run_name=exp_name, nested=True)

        print("="*5, reg_name, "="*5)
        print("--",params,"--")
        # params = {'method': 'sto', 'lr': 0.01, 'momentum': 0.99, 'initialize':
↪ 'zeros', 'l': 0.1}
        # #######
        type_of_regression = str_to_class(reg)    #Ridge, Lasso, ElasticNet
        model = type_of_regression(**params)
        if pol == True:
            model.polynomial = True
        model.num_epochs = 100
        # model.momentum = None
        model.fit(X_train, y_train)
        val_mse.append(np.mean(model.kfold_scores_mse))
        val_r2.append(np.mean(model.kfold_scores_r2))

        signature = mlflow.models.infer_signature(X_train, model.
↪predict(X_train))
        mlflow.sklearn.log_model(model, artifact_path='model',␣
↪signature=signature)

        # #######

        mlflow.end_run()

    selected_exps['Val_MSE'] = val_mse
    selected_exps['Val_R2'] = val_r2

    return selected_exps
```

Experiment01 - regression types To compare the performance of the linear and polynomial regression(2degree) with lasso, Ridge, ElasticNet and No regularization, cross-validation with 5 folds will be run for each regressions. Then, compare mse and r2 of validation set and choose the

best one. Although r2 is monitored, val_mse will be the main factor to decide which regression is better as I assume that val_mse is a more decisive factor. All others parameters will be set the same for all iterations.

[ ]:
```
# Creating experiment in MLflow
import mlflow
import os
mlflow.set_tracking_uri("http://localhost:5000")
os.environ["LOGNAME"] = "knl"
mlflow.set_experiment(experiment_name="Experiment01_regression_types")

# Running experiments
# experiment(experiments,test_on,regs='Ridge',polyno=False,method='batch',lr=0.
  ↪01,initi='xavier',mmt=0.99)
method,lr,initi,mmt = 'batch',0.01,'xavier',0.99
Exp1_Result =␣
  ↪experiment(experiments=experiments,test_on='regs',method=method,lr=lr,initi=initi,mmt=mmt)
```

```
2024/09/06 20:10:59 INFO mlflow.tracking.fluent: Experiment with name
'Experiment01_regression_types' does not exist. Creating a new experiment.

===== Polynomial_Ridge =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:11:03 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/a59e490ad
2c04489b4cf9a441d3b1482.
2024/09/06 20:11:03 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 83.03858958712567

2024/09/06 20:11:07 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/d6fde601f
b024714a2f13a81a5257e9d.
2024/09/06 20:11:07 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 83.37576629071452

2024/09/06 20:11:10 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/2a08c8679
ff74faeb908f97336a69a6f.
2024/09/06 20:11:10 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 84.18835052332062

2024/09/06 20:11:13 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/20189c2ba
4324cf98a29bb2d6aaf479d.
```

```
2024/09/06 20:11:13 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 83.00056791240807

2024/09/06 20:11:16 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/d2c240c16
3d24b87854d7862731856bb.
2024/09/06 20:11:16 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 84.28138933406224

2024/09/06 20:11:19 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: ht
tp://localhost:5000/#/experiments/350725065963083217/runs/fef24fd2c81e4b2db9e076
4d89f96021.
2024/09/06 20:11:19 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Linear_Ridge =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:11:22 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/385f038fe
9ec44ceb177086a5308668c.
2024/09/06 20:11:22 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 137.40913005041182

2024/09/06 20:11:25 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/dbc9025db
9b7437f95420065f1910a47.
2024/09/06 20:11:25 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 137.16378253851786

2024/09/06 20:11:28 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/56720c45e
d60498781240938186f78cd.
2024/09/06 20:11:28 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 138.81664914098405

2024/09/06 20:11:31 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/570986574
50a4cd4bc812ea381613135.
2024/09/06 20:11:31 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.
```

```
Fold 3: 136.76723118955198

2024/09/06 20:11:34 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/013327cd2
2e540df92434012beb003c5.
2024/09/06 20:11:34 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 137.28275748618083

2024/09/06 20:11:38 INFO mlflow.tracking._tracking_service.client:  View run
reg-Linear_Ridge-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: http:/
/localhost:5000/#/experiments/350725065963083217/runs/005d4cbbca6948c99f37f0b02e
8ec4ff.
2024/09/06 20:11:38 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Polynomial_Lasso =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:11:41 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/b41c4017d
53541278ed5cac2b6397d4d.
2024/09/06 20:11:41 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 83.07575656918716

2024/09/06 20:11:44 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/320f7cf23
43d4c40a97be8f0ad331359.
2024/09/06 20:11:44 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 84.52684655660988

2024/09/06 20:11:47 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/d1d6c853f
4ce4d5faecbafe7be0ff7f8.
2024/09/06 20:11:47 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 84.66895276928558

2024/09/06 20:11:50 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/73b68ff6e
0e84ba88c3dc9257adcf2f6.
2024/09/06 20:11:50 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 83.17957329033108
```

```
2024/09/06 20:11:54 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/a4d79ff99
d1d4c06b2e755aeafe139fd.
2024/09/06 20:11:54 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 85.05265700682457

2024/09/06 20:11:57 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Lasso-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: ht
tp://localhost:5000/#/experiments/350725065963083217/runs/6fd6110643474d8ca3ffda
7ca9f5ffd5.
2024/09/06 20:11:57 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Linear_Lasso =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:12:00 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/0995c2a4a
d2547d5bf240519335d79e9.
2024/09/06 20:12:00 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 137.05312604050184

2024/09/06 20:12:03 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/10a4b7dd7
c534e0688104d833d68ddf7.
2024/09/06 20:12:03 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 136.85280117778706

2024/09/06 20:12:07 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/de79319c1
e104f4ab67fe8bd0db3812f.
2024/09/06 20:12:07 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 138.19115170443504

2024/09/06 20:12:10 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/b27432f32
ca844018f2bb8ada40e0e4a.
2024/09/06 20:12:10 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 136.80492371174856

2024/09/06 20:12:13 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/6018a642b
1d44b898788d0bf8d8d357f.
```

```
2024/09/06 20:12:13 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 137.444429954092

2024/09/06 20:12:16 INFO mlflow.tracking._tracking_service.client:  View run
reg-Linear_Lasso-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: http:/
/localhost:5000/#/experiments/350725065963083217/runs/0d1371b7c4c84575b1ac5d41ac
71c569.
2024/09/06 20:12:16 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Polynomial_ElasticNet =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:12:20 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/b3d85e10c
ef94825a5b6bef0cf97fea8.
2024/09/06 20:12:20 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 83.48004262396066

2024/09/06 20:12:23 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/f471aeee4
a2f4561bfc100262858e3fd.
2024/09/06 20:12:23 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 83.76473366431819

2024/09/06 20:12:26 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/1181a1f90
ec64fc1b064892ca8cf8aa3.
2024/09/06 20:12:26 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 84.3226925751748

2024/09/06 20:12:29 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/7614e2eef
ca742f8ace34ea79c382c9a.
2024/09/06 20:12:29 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 82.96898845655906

2024/09/06 20:12:32 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/a8d92ec38
c654c5d8a8c7db8efb32c13.
2024/09/06 20:12:32 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.
```

```
Fold 4: 84.21178238983353

2024/09/06 20:12:36 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_ElasticNet-method-batch-lr-0.01-momentum-0.99-initialize-xavier
at: http://localhost:5000/#/experiments/350725065963083217/runs/d2afb555552a4c65
a96a9bc01de1127b.
2024/09/06 20:12:36 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Linear_ElasticNet =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:12:39 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/3f580bd60
fb643168ad71a4cdb2935d8.
2024/09/06 20:12:39 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 136.96980547873628

2024/09/06 20:12:42 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/b4cde887e
72c4e119c7750c35b6321f5.
2024/09/06 20:12:42 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 136.96319064459195

2024/09/06 20:12:45 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/0f1c672bf
e784368b6e8930abf5b6f34.
2024/09/06 20:12:45 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 137.99669045009313

2024/09/06 20:12:47 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/453d48b43
1ad47f5b6643be369720914.
2024/09/06 20:12:47 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 137.06172585398338

2024/09/06 20:12:50 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/e08c0358e
3ac40d6b49c57b46b8e659b.
2024/09/06 20:12:50 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 136.93392708135056
```

```
2024/09/06 20:12:54 INFO mlflow.tracking._tracking_service.client:  View run
reg-Linear_ElasticNet-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: h
ttp://localhost:5000/#/experiments/350725065963083217/runs/b5217647804e4c4dbba40
c1d5e5ee755.
2024/09/06 20:12:54 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Polynomial_Normal =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:12:57 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/1452eaeeb
47b4305a25383409d6c6f56.
2024/09/06 20:12:57 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 83.16970412437567

2024/09/06 20:13:00 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/f5e119ff5
df24b24a179e597ea89269f.
2024/09/06 20:13:00 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 83.41273442339443

2024/09/06 20:13:03 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/dbca9b286
5d34670a3f32571d433eb73.
2024/09/06 20:13:03 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 84.56016043761626

2024/09/06 20:13:07 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/b7c372b40
d73420c8158a47c529d42b8.
2024/09/06 20:13:07 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 83.15647995962912

2024/09/06 20:13:10 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/fa158062e
07943bd87c17760e043fa7e.
2024/09/06 20:13:10 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 84.23422076385049

2024/09/06 20:13:14 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_Normal-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: h
ttp://localhost:5000/#/experiments/350725065963083217/runs/821f02b847bd4b84bad4c
```

```
395b1f3e7cc.
2024/09/06 20:13:14 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

===== Linear_Normal =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:13:17 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/350725065963083217/runs/b78b62a2f
88a41feb43546905460fa6b.
2024/09/06 20:13:17 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 0: 137.0680830448679

2024/09/06 20:13:21 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/350725065963083217/runs/7f0bdf3e8
cec481eb3fabba43edcdc33.
2024/09/06 20:13:21 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 1: 137.47301287611594

2024/09/06 20:13:24 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/350725065963083217/runs/8c52911aa
a93453484ef78b9a8c7126e.
2024/09/06 20:13:24 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 2: 138.22015790399513

2024/09/06 20:13:27 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/350725065963083217/runs/f92e8e70d
9714e868d8700c9b05cc721.
2024/09/06 20:13:27 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 3: 136.76641813153086

2024/09/06 20:13:30 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/350725065963083217/runs/5e0e80ae7
6044a71929b85f61d392199.
2024/09/06 20:13:30 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.

Fold 4: 137.5764044642663

2024/09/06 20:13:33 INFO mlflow.tracking._tracking_service.client:   View run
reg-Linear_Normal-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: http:
//localhost:5000/#/experiments/350725065963083217/runs/ddc7934690214614821080773
78d2eb0.
2024/09/06 20:13:33 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/350725065963083217.
```

[ ]:
```
# Checking average mse and r2 to choose the model
Exp1_Result.sort_values('Val_MSE')
```

[ ]:

	Regression	Polynomial	GD_methods	Momentum_Term	Weight_Initialization	Learning_Rates	Val_MSE	Val_R2
21	Ridge	True	batch	0.99	xavier	0.01	83.578	0.990
453	Normal	True	batch	0.99	xavier	0.01	83.706	0.990
309	ElasticNet	True	batch	0.99	xavier	0.01	83.748	0.990
165	Lasso	True	batch	0.99	xavier	0.01	84.102	0.990
381	ElasticNet	False	batch	0.99	xavier	0.01	137.184	0.994
237	Lasso	False	batch	0.99	xavier	0.01	137.266	0.994
525	Normal	False	batch	0.99	xavier	0.01	137.422	0.994
93	Ridge	False	batch	0.99	xavier	0.01	137.488	0.994

The results are quite clear. Polynomial regressions out perform linear regression and Ridge got the lowest average val_MSE. The r2 scores are quite the some for all. Hence, Polynomial Ridge regression are selected in this experiment

Experiment02- gradeint calculation methods This experiment is to compare stochastic, mini-batch and batch gradient descent methods. The experiment setting are the same as Experiment01

[ ]:
```
mlflow.set_experiment(experiment_name="Experiment02_gradeint_calculate_method")
reg,polyno,lr,initi,mmt = 'Ridge',True,0.01,'xavier',0.99
Exp2_Result =␣
 ↪experiment(experiments=experiments,test_on='method',regs=reg,polyno=polyno,lr=lr,initi=init
```

```
2024/09/06 20:16:18 INFO mlflow.tracking.fluent: Experiment with name
'Experiment02_gradeint_calculate_method' does not exist. Creating a new
experiment.

===== Polynomial_Ridge =====
-- {'method': 'batch', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:16:22 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/423464395348543654/runs/b3d52b92d
1a847af81566702da61c28e.
2024/09/06 20:16:22 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.
```

```
Fold 0: 82.97150894419306

2024/09/06 20:16:25 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/423464395348543654/runs/0c6be7e11
c5148428882f325aa9039fa.
2024/09/06 20:16:25 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 1: 83.3051744992913

2024/09/06 20:16:29 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/423464395348543654/runs/f4758d8f9
f6840aca77fa5ac31f96c12.
2024/09/06 20:16:29 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 2: 83.85679518571399

2024/09/06 20:16:33 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/423464395348543654/runs/cbd673402
f1f4598a7fee8e630c89de0.
2024/09/06 20:16:33 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 3: 83.06036864685196

2024/09/06 20:16:36 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/423464395348543654/runs/fbe3a4d8e
26b4cfcb8525dedb15f0113.
2024/09/06 20:16:36 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 4: 84.32597770426167

2024/09/06 20:16:40 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-batch-lr-0.01-momentum-0.99-initialize-xavier at: ht
tp://localhost:5000/#/experiments/423464395348543654/runs/7de04e4aa26246e9933fff
3a75a50cf1.
2024/09/06 20:16:40 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:16:44 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/423464395348543654/runs/6f5bd9c6e
ba54237be2a1645c0088c51.
2024/09/06 20:16:44 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 0: 5.120736060587965
```

```
2024/09/06 20:16:48 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/423464395348543654/runs/f59d5b608
74b4d6f881286aabbbcb0cf.
2024/09/06 20:16:48 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 1: 4.9975215405879165

2024/09/06 20:16:51 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/423464395348543654/runs/00bbe29ba
831443b9c84a84bcca8ba8f.
2024/09/06 20:16:51 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 2: 4.996099219187886

2024/09/06 20:16:55 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/423464395348543654/runs/c1f2c85c3
33f4db89a1bc4304dcae88d.
2024/09/06 20:16:55 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 3: 4.138499717933569

2024/09/06 20:16:59 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/423464395348543654/runs/213ae2efa
e494a9b9ce651f0d1c43ee3.
2024/09/06 20:16:59 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 4: 5.082126286719772

2024/09/06 20:17:03 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.99-initialize-xavier at: htt
p://localhost:5000/#/experiments/423464395348543654/runs/528e5cb3a8d641ca8751ebe
c9b9df6ad.
2024/09/06 20:17:03 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

===== Polynomial_Ridge =====
-- {'method': 'sto', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:17:06 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/423464395348543654/runs/138f24756
7254e9284ab0858eaad4d03.
2024/09/06 20:17:06 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 0: 3047.833591857777

2024/09/06 20:17:25 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/423464395348543654/runs/a7693b176
36a4a1f930939f19b3cec2f.
```

```
2024/09/06 20:17:25 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 1: 3653.6028874550207

2024/09/06 20:17:44 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/423464395348543654/runs/73d4332d6
77643298699f2db071480bb.
2024/09/06 20:17:44 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 2: 2692.574849053564

2024/09/06 20:18:03 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/423464395348543654/runs/30b71b3e1
07947f39bbdd9258951f6c1.
2024/09/06 20:18:03 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 3: 2107.629784301589

2024/09/06 20:18:22 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/423464395348543654/runs/6b73e6c5d
2be46d8920ff71bc0f83c42.
2024/09/06 20:18:22 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.

Fold 4: 3205.021378627821

2024/09/06 20:18:25 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-sto-lr-0.01-momentum-0.99-initialize-xavier at: http
://localhost:5000/#/experiments/423464395348543654/runs/a4a5b0a8f2b64ed7853d5b52
b1359d9d.
2024/09/06 20:18:25 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/423464395348543654.
```

[ ]:
```
Exp2_Result.sort_values('Val_MSE')
```

[ ]:

	Regression	Polynomial	GD_methods	Momentum_Term	Weight_Initialization	Learning_Rates	Val_MSE	Val_R2
45	Ridge	True	mini	0.99	xavier	0.01	4.868	0.856
21	Ridge	True	batch	0.99	xavier	0.01	83.506	0.990
69	Ridge	True	sto	0.99	xavier	0.01	2941.330	0.640

In this experiment, mini batch gradient descent method got the lowest MSE.

Experiment03- Momentum Terms This experiment is to find the best momentum terms. The experiment setting are the same as Experiment01

[ ]:
```
mlflow.set_experiment(experiment_name="Experiment03_momentums")
reg,polyno,method,lr,initi = 'Ridge',True,'mini',0.01,'xavier'
Exp3_Result =␣
  ↪experiment(experiments=experiments,test_on='mmt',regs=reg,polyno=polyno,method=method,lr=lr
```

```
2024/09/06 20:19:14 INFO mlflow.tracking.fluent: Experiment with name
'Experiment03_momentums' does not exist. Creating a new experiment.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.0, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:19:18 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/999712658963448885/runs/d4f6b778e
17d477c90fa53e4917ba68e.
2024/09/06 20:19:18 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 0: 1.8973707668951014

2024/09/06 20:19:22 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/999712658963448885/runs/5da9f9690
6e74323bef7604e20ac0c19.
2024/09/06 20:19:22 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 1: 1.8451154609960874

2024/09/06 20:19:26 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/999712658963448885/runs/a992ecc97
e36468e8ed93de3bb3947de.
2024/09/06 20:19:26 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 2: 1.7658005017272715

2024/09/06 20:19:29 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/999712658963448885/runs/11c63f7a5
b6a4dbe8b3bedf08929ab68.
2024/09/06 20:19:29 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 3: 1.3981796890797147

2024/09/06 20:19:33 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/999712658963448885/runs/00b34bb73
7ee4b9db8b2cf0469ef32ec.
2024/09/06 20:19:33 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 4: 1.8602017084622968
```

```
2024/09/06 20:19:36 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.0-initialize-xavier at: http
://localhost:5000/#/experiments/999712658963448885/runs/961832a0478c494daf1f0529
712948b7.
2024/09/06 20:19:36 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.4, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:19:40 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/999712658963448885/runs/9e01a64bc
17f4944a776ba4f2bee757c.
2024/09/06 20:19:40 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 0: 1.869324856366238

2024/09/06 20:19:43 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/999712658963448885/runs/49ca2351c
9df4ee0bd10bf7c3fe6ec67.
2024/09/06 20:19:43 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 1: 1.812333124442452

2024/09/06 20:19:47 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/999712658963448885/runs/126d16d22
031405388f29ceaa7328feb.
2024/09/06 20:19:47 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 2: 1.900115186884608

2024/09/06 20:19:50 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/999712658963448885/runs/8cffc4d12
fbe41788ba81d4d01372eb3.
2024/09/06 20:19:50 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 3: 1.4062405184440474

2024/09/06 20:19:54 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/999712658963448885/runs/45390f21b
185445e9ac4a7af5fa4a748.
2024/09/06 20:19:54 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 4: 1.85223331453306

2024/09/06 20:19:57 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.4-initialize-xavier at: http
://localhost:5000/#/experiments/999712658963448885/runs/0a54207f88bb418a94e14a38
```

```
fd4fa1c3.
2024/09/06 20:19:57 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.7, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:20:01 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/999712658963448885/runs/6f74f510a
50941918ad7cd77a7ee4aeb.
2024/09/06 20:20:01 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 0: 1.8852725282230127

2024/09/06 20:20:05 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/999712658963448885/runs/bcf5bd35a
cff46daaccf2a2d9e615a16.
2024/09/06 20:20:05 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 1: 1.7991420392540827

2024/09/06 20:20:09 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/999712658963448885/runs/674b77912
b3c46278b1d33e47fa6eb6e.
2024/09/06 20:20:09 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 2: 1.7861421779503808

2024/09/06 20:20:13 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/999712658963448885/runs/a87b57735
44147a98df66f2ad8eafedf.
2024/09/06 20:20:13 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 3: 1.418140641153034

2024/09/06 20:20:16 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/999712658963448885/runs/8b1063fd3
38f44c393cb7b06f3d4ecfb.
2024/09/06 20:20:16 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 4: 1.836566085958682

2024/09/06 20:20:20 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.7-initialize-xavier at: http
://localhost:5000/#/experiments/999712658963448885/runs/b4d876c86a4147afbaccaeb3
cb2c982d.
2024/09/06 20:20:20 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.
```

```
===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.99, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:20:24 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/999712658963448885/runs/f427d7190
6c34a27b0c90f3b0a1960a7.
2024/09/06 20:20:24 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 0: 5.033531294460096

2024/09/06 20:20:28 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/999712658963448885/runs/5f7563794
d454485863c9e87b89ed33d.
2024/09/06 20:20:28 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 1: 4.970865183318406

2024/09/06 20:20:32 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/999712658963448885/runs/9a076908f
43347b3b95070589bc914d1.
2024/09/06 20:20:32 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 2: 4.991758827891181

2024/09/06 20:20:36 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/999712658963448885/runs/c99345c83
23d406c927a9bb5650be651.
2024/09/06 20:20:36 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 3: 4.187047002455652

2024/09/06 20:20:39 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/999712658963448885/runs/a942e78f3
30b4872bfe059a4fc993be8.
2024/09/06 20:20:39 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.

Fold 4: 5.059789733186291

2024/09/06 20:20:42 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.99-initialize-xavier at: htt
p://localhost:5000/#/experiments/999712658963448885/runs/d63f43b987ef4e669a51647
94b4a4a0b.
2024/09/06 20:20:42 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/999712658963448885.
```

[ ]:
```
Exp3_Result.sort_values('Val_MSE')
```

[ ]:

	Regression	Polynomial	GD_methods	Momentum_Term	Weight_Initialization	Learning_Rates	Val_MSE	Val_R2
39	Ridge	True	mini	0.70	xavier	0.01	1.748	0.594
27	Ridge	True	mini	0.00	xavier	0.01	1.756	0.592
33	Ridge	True	mini	0.40	xavier	0.01	1.768	0.596
45	Ridge	True	mini	0.99	xavier	0.01	4.848	0.856

The momentum term 0.7 score the lowest mse

Experiment04- Weight Initialization This experiment is to compare MSE and R2 values for zeros weight initialization and xavier methods . The experiment setting are the same as Experiment01

[ ]:
```
mlflow.set_experiment(experiment_name="Experiment04_weight_initialization")
reg,polyno,method,lr,mmt = 'Ridge',True,'mini',0.01,0.7
Exp4_Result =␣
  ↪experiment(experiments=experiments,test_on='initi',regs=reg,polyno=polyno,method=method,lr=
```

```
2024/09/06 20:22:23 INFO mlflow.tracking.fluent: Experiment with name
'Experiment04_weight_initialization' does not exist. Creating a new experiment.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.7, 'initialize': 'zeros', 'l':
0.1} --

2024/09/06 20:22:28 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/773630282766161491/runs/f1d883224
56b43deae938b92ce9d5537.
2024/09/06 20:22:28 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 0: 1.8712982516542407

2024/09/06 20:22:32 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/773630282766161491/runs/1798c3d7f
ef544d5b263878dd29a1730.
2024/09/06 20:22:32 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 1: 2.077713397572021

2024/09/06 20:22:35 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/773630282766161491/runs/92f63eaca
5c246cf95e056200b402c74.
2024/09/06 20:22:35 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.
```

```
Fold 2: 1.796422220052002

2024/09/06 20:22:37 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/773630282766161491/runs/d41f7fc61
f824e4d9621ba55b787abfa.
2024/09/06 20:22:37 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 3: 1.4525099428789658

2024/09/06 20:22:41 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/773630282766161491/runs/44c1ec8c2
4174e4bb4898c127ba98af1.
2024/09/06 20:22:41 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 4: 1.8440975404568525

2024/09/06 20:22:45 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.7-initialize-zeros at: http:
//localhost:5000/#/experiments/773630282766161491/runs/9e146b3c6d114ffc83f3c869a
c9f71a6.
2024/09/06 20:22:45 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.7, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:22:49 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/773630282766161491/runs/729e581d4
ed34b00ac8de4b0181cc51f.
2024/09/06 20:22:49 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 0: 1.8925397646171622

2024/09/06 20:22:53 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/773630282766161491/runs/962d56f26
22b4916bb0e5f43f0cca5c0.
2024/09/06 20:22:53 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 1: 1.8034440147608126

2024/09/06 20:22:57 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/773630282766161491/runs/171ed2b27
d084270a00a36c855568f3d.
2024/09/06 20:22:57 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 2: 1.7725392270951563
```

```
2024/09/06 20:23:00 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/773630282766161491/runs/a3c6e7264
14f4fc688ed8aeea0a8fd35.
2024/09/06 20:23:00 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 3: 1.4824229583307387

2024/09/06 20:23:04 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/773630282766161491/runs/633d25998
12a4daf9c3ee9e9076a5dbd.
2024/09/06 20:23:04 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.

Fold 4: 1.849038908092312

2024/09/06 20:23:08 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.7-initialize-xavier at: http
://localhost:5000/#/experiments/773630282766161491/runs/30b70e107c954df0be502aac
dc0712f5.
2024/09/06 20:23:08 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/773630282766161491.
```

[ ]:
```
Exp4_Result.sort_values('Val_MSE')
```

[ ]:

	Regression	Polynomial	GD_methods	Momentum_Term	Weight_Initialization	Learning_Rates	Val_MSE	Val_R2
39	Ridge	True	mini	0.7	xavier	0.01	1.758	0.596
36	Ridge	True	mini	0.7	zeros	0.01	1.808	0.606

In this experiment,Xavier's method has a slightly lower MSE and r2 score. As I assume the MSE is more important, Xavier's method is selected

Experiment05- Learning Rate This experiment is to find the learning rate in 0.01,0.001 and 0.0001 . The experiment setting are the same as Experiment01

[ ]:
```
mlflow.set_experiment(experiment_name="Experiment05_Learning_Rates")
reg,polyno,method,initi,mmt = 'Ridge',True,'mini','xavier',0.7
Exp5_Result =␣
 ↪experiment(experiments=experiments,test_on='lr',regs=reg,polyno=polyno,method=method,initi=
```

```
2024/09/06 20:36:17 INFO mlflow.tracking.fluent: Experiment with name
'Experiment05_Learning_Rates' does not exist. Creating a new experiment.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.01, 'momentum': 0.7, 'initialize': 'xavier', 'l':
0.1} --
```

```
2024/09/06 20:36:21 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/683297428701201410/runs/2d187f4c4
de94c29bdc461a238f92159.
2024/09/06 20:36:21 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 0: 1.897108826112801

2024/09/06 20:36:25 INFO mlflow.tracking._tracking_service.client:  View run
Fold-1 at: http://localhost:5000/#/experiments/683297428701201410/runs/f2769735b
1144a7fa00af48a262ef2de.
2024/09/06 20:36:25 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 1: 1.82300315710579

2024/09/06 20:36:29 INFO mlflow.tracking._tracking_service.client:  View run
Fold-2 at: http://localhost:5000/#/experiments/683297428701201410/runs/cca5149cf
9034264a4c5d96e0165b5d6.
2024/09/06 20:36:29 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 2: 1.7919602289045482

2024/09/06 20:36:32 INFO mlflow.tracking._tracking_service.client:  View run
Fold-3 at: http://localhost:5000/#/experiments/683297428701201410/runs/b269aae37
bc842eeaa7e2ffeb4e3563b.
2024/09/06 20:36:32 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 3: 1.439870576743772

2024/09/06 20:36:36 INFO mlflow.tracking._tracking_service.client:  View run
Fold-4 at: http://localhost:5000/#/experiments/683297428701201410/runs/66680aa70
4d04a4d8563e37aafabf99d.
2024/09/06 20:36:36 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 4: 1.8421690501836474

2024/09/06 20:36:39 INFO mlflow.tracking._tracking_service.client:  View run
reg-Polynomial_Ridge-method-mini-lr-0.01-momentum-0.7-initialize-xavier at: http
://localhost:5000/#/experiments/683297428701201410/runs/8d77e45343274d4eb8f41c1c
44ec3617.
2024/09/06 20:36:39 INFO mlflow.tracking._tracking_service.client:  View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.001, 'momentum': 0.7, 'initialize': 'xavier', 'l':
0.1} --

2024/09/06 20:36:43 INFO mlflow.tracking._tracking_service.client:  View run
Fold-0 at: http://localhost:5000/#/experiments/683297428701201410/runs/adc50563e
1bd4d43bd0b86f805fad173.
```

```
2024/09/06 20:36:43 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 0: 2.6714023638925677

2024/09/06 20:36:46 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/68329742870120141O/runs/a113fec1b
c7b487c8a841659b21b7b79.
2024/09/06 20:36:46 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 1: 2.56275860963246

2024/09/06 20:36:49 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/68329742870120141O/runs/47dcf9d5f
f184dedbfc30a8c78425f6f.
2024/09/06 20:36:49 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 2: 2.5302966929830824

2024/09/06 20:36:53 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/68329742870120141O/runs/6f2b395f3
b4b4fd6a6d93ccff77ac01a.
2024/09/06 20:36:53 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 3: 1.97824487092019

2024/09/06 20:36:56 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/68329742870120141O/runs/457db200d
6674a9485ce12f4caf9d54b.
2024/09/06 20:36:56 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 4: 2.56342713743692

2024/09/06 20:36:59 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.001-momentum-0.7-initialize-xavier at: htt
p://localhost:5000/#/experiments/683297428701201410/runs/668c5bc69b6449a9926220e
3047e926f.
2024/09/06 20:36:59 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

===== Polynomial_Ridge =====
-- {'method': 'mini', 'lr': 0.0001, 'momentum': 0.7, 'initialize': 'xavier',
'l': 0.1} --

2024/09/06 20:37:03 INFO mlflow.tracking._tracking_service.client:   View run
Fold-0 at: http://localhost:5000/#/experiments/68329742870120141O/runs/1fd5c3039
3d74e02a56d52e282b9a738.
2024/09/06 20:37:03 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.
```

```
Fold 0: 11.686199116187518

2024/09/06 20:37:06 INFO mlflow.tracking._tracking_service.client:   View run
Fold-1 at: http://localhost:5000/#/experiments/683297428701201410/runs/b57d480db
df14f11ac2762f251cb9c21.
2024/09/06 20:37:06 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 1: 11.531878121654833

2024/09/06 20:37:10 INFO mlflow.tracking._tracking_service.client:   View run
Fold-2 at: http://localhost:5000/#/experiments/683297428701201410/runs/167074068
dcb4453aefa19dc8661a224.
2024/09/06 20:37:10 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 2: 11.628959730709893

2024/09/06 20:37:13 INFO mlflow.tracking._tracking_service.client:   View run
Fold-3 at: http://localhost:5000/#/experiments/683297428701201410/runs/f377f158b
263480284f56b6329387f9a.
2024/09/06 20:37:13 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 3: 10.974608256204231

2024/09/06 20:37:16 INFO mlflow.tracking._tracking_service.client:   View run
Fold-4 at: http://localhost:5000/#/experiments/683297428701201410/runs/a2bd8176b
4624a8f872c1c70615efd06.
2024/09/06 20:37:16 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.

Fold 4: 11.908785276563975

2024/09/06 20:37:20 INFO mlflow.tracking._tracking_service.client:   View run
reg-Polynomial_Ridge-method-mini-lr-0.0001-momentum-0.7-initialize-xavier at: ht
tp://localhost:5000/#/experiments/683297428701201410/runs/cecfd50817b74d24a49e92
ad495d94ae.
2024/09/06 20:37:20 INFO mlflow.tracking._tracking_service.client:   View
experiment at: http://localhost:5000/#/experiments/683297428701201410.
```

[ ]:
```
Exp5_Result.sort_values('Val_MSE')
```

[ ]:
```
   Regression  Polynomial GD_methods  Momentum_Term Weight_Initialization  \
39      Ridge        True       mini            0.7                 xavier
40      Ridge        True       mini            0.7                 xavier
41      Ridge        True       mini            0.7                 xavier

    Learning_Rates  Val_MSE  Val_R2
39          0.0100    1.758   0.598
40          0.0010    2.460   0.710
41          0.0001   11.546   0.940
```

In this experiment, the learning rate of 0.01 has the lowest MSE

3 7. Testing

Now, the best model will be searched and loaded to test on test set

[ ]:
```
# Save the model
model_uri = 'runs:/8d77e45343274d4eb8f41c1c44ec3617/model'
mlflow.artifacts.download_artifacts(model_uri,dst_path="./")
```

[ ]:
```
'/home/knl/DSAI/ML/A2 - Assignment/code/model'
```

[ ]:
```
# loading the model
filename = 'model/'
best_model = mlflow.pyfunc.load_model(filename)
best_model = best_model.get_raw_model()
```

[ ]:
```
# do inference on the test set
yhat = best_model.predict(X_test)
```

[ ]:
```
# MSE of the test set
best_model.mse(ypred=yhat,ytrue=y_test)
```

[ ]:
```
np.float64(1.5635440164345504)
```

[ ]:
```
# R2 of the test set
best_model.r2_score(ypred=yhat,ytrue=y_test)
```

[ ]:
```
np.float64(0.551287877583187)
```

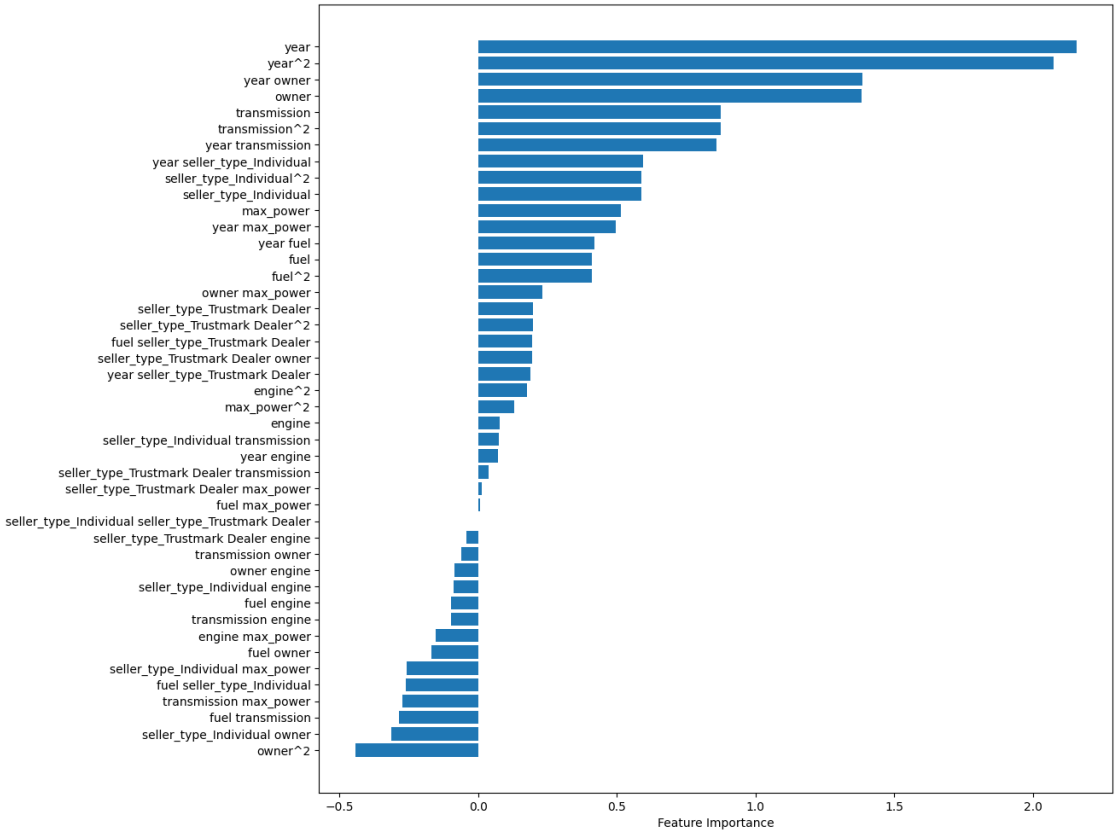
MSE and r2 of the test set are not much different from validation set. The model performance is good.

3.1 8. Analysis: Feature Importance

Now, we will analyze which features are more important to predict the car price

Let's plot the feature importance

[ ]:
```
plt.figure(figsize=(12, 12))
best_model.plot_feature_importance()
```



4 9. Inference

[ ]:
```
# predicted value
str(np.exp(best_model.predict([X_test.iloc[0]])[0]))
```

[ ]:
```
'281958.3277194781'
```

[ ]:
```
# true value
str(np.exp(y_test.iloc[0]))
```

[ ]:
```
'225000.00000000015'
```

4.0.1 10. Report

Data Preprocessing is the the same as A1 assignment except the year feature. The year feature need to be scaled as it makes the gradient makes it million to infinity. Although this feature is ordinal (normally suitable with label encoding), I normalize this feature with min-max scaler method considering the years that are not in the training set. I take the year cars were invented as min and the current year as max.

In the modeling step, there are six different choices, which are regression, polynomial(test only 2 degree),gradient descent methods, momentum terms(test 4 values - zero as without momentum), weight initialization methods and learning rates, to optimize the model performance. There are 576 different combinations to experiment, which is quite computing resources intensive. So, I chose a different approach that choosing a parameter or regression type at a time by setting others as the same. After deciding which is the best from experiment, I take it as default parameter in the next experiment. In this approach, there are five experiments as follow: - Choosing the regression types (8) - Choosing gradient descent methods (3) - Choosing momentum terms (4) - Choosing weight initialization (2) - Choosing Learning Rates (3) The experiment runs is reduced down to 20 from 576. All trainings are done with 100 epoch.

After the experiments, I find out that the best model is polynomial regression with ridge regularization having the parameters of 0.01 as learning rate, mini-batch as gradient descent method, 0.7 as momentum term and xavier weight initialization method. This model has around average 1.7 mse and 0.6 r2 of the val set from running 5 fold cross-validation. The test mse and r2 are also not much different from these numbers. It can be observed that the features has non-linear relationships with the target as the polynomial regression is much better than linear regression. Then, I think the mini-batch out performs other two methods as it increases the generalizability compared to "batch". It can also be found that the larger learning rate is more effective. The others parameters make only slight difference. The summary table and the scatter plots of Val MSE and r2 of each fold in are shown in the below.

In the feature importance plot, it can be seen that the year feature is the most important feature. The top three features are year and its featuring crossings following transmission, owner, seller types and max_power.

[ ]:
```
# Summarizing the 20 runs of the 5 experiments
Comparison = pd.
  ↪concat([Exp1_Result,Exp2_Result,Exp3_Result,Exp4_Result,Exp5_Result],axis=0)
Comparison.sort_values('Val_MSE')
```

[ ]:

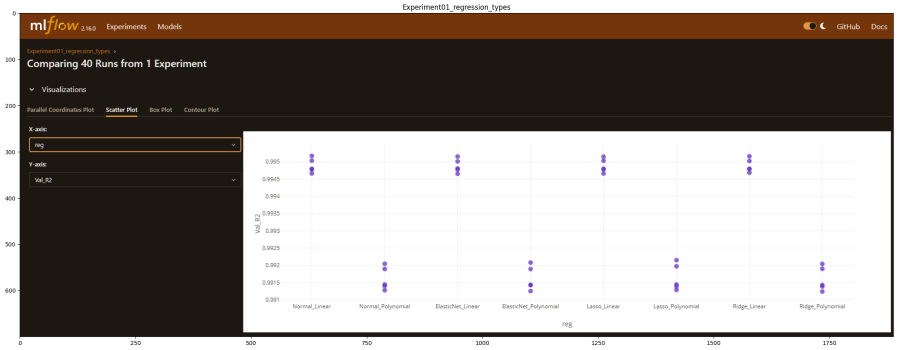
	Regression	Polynomial	GD_methods	Momentum_Term	Weight_Initialization	\
39	Ridge	True	mini	0.70	xavier	
27	Ridge	True	mini	0.00	xavier	
39	Ridge	True	mini	0.70	xavier	
39	Ridge	True	mini	0.70	xavier	
33	Ridge	True	mini	0.40	xavier	
36	Ridge	True	mini	0.70	zeros	
40	Ridge	True	mini	0.70	xavier	
45	Ridge	True	mini	0.99	xavier	
45	Ridge	True	mini	0.99	xavier	
41	Ridge	True	mini	0.70	xavier	
21	Ridge	True	batch	0.99	xavier	
21	Ridge	True	batch	0.99	xavier	
453	Normal	True	batch	0.99	xavier	
309	ElasticNet	True	batch	0.99	xavier	
165	Lasso	True	batch	0.99	xavier	
381	ElasticNet	False	batch	0.99	xavier	

```
237       Lasso       False      batch           0.99                xavier
525      Normal       False      batch           0.99                xavier
93        Ridge       False      batch           0.99                xavier
69        Ridge        True        sto           0.99                xavier

     Learning_Rates   Val_MSE  Val_R2
39           0.0100     1.748   0.594
27           0.0100     1.756   0.592
39           0.0100     1.758   0.598
39           0.0100     1.758   0.596
33           0.0100     1.768   0.596
36           0.0100     1.808   0.606
40           0.0010     2.460   0.710
45           0.0100     4.848   0.856
45           0.0100     4.868   0.856
41           0.0001    11.546   0.940
21           0.0100    83.506   0.990
21           0.0100    83.578   0.990
453          0.0100    83.706   0.990
309          0.0100    83.748   0.990
165          0.0100    84.102   0.990
381          0.0100   137.184   0.994
237          0.0100   137.266   0.994
525          0.0100   137.422   0.994
93           0.0100   137.488   0.994
69           0.0100  2941.330   0.640
```

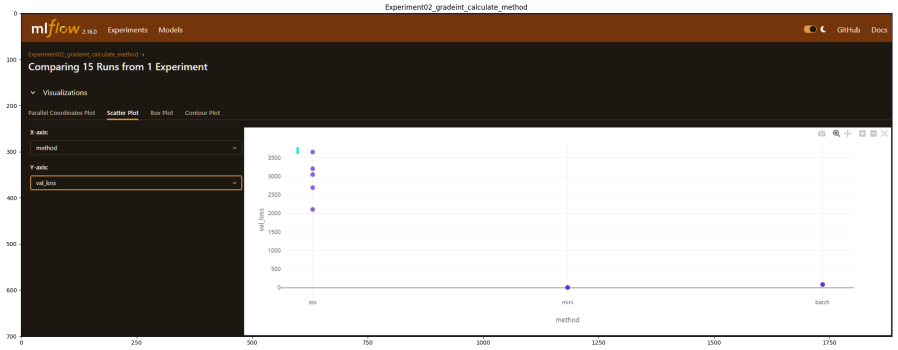
[ ]:
```
import cv2 as cv
Exp01 = cv.imread('./Images/Exp01.png')
Exp02 = cv.imread('./Images/Exp02.png')
Exp03 = cv.imread('./Images/Exp03.png')
Exp04 = cv.imread('./Images/Exp04.png')
Exp05 = cv.imread('./Images/Exp05.png')
plt.figure(figsize=(60,60))

plt.subplot(5,1,1),plt.imshow(Exp01),plt.title('Experiment01_regression_types')
plt.subplot(5,1,2),plt.imshow(Exp02),plt.
  ↪title('Experiment02_gradeint_calculate_method')
plt.subplot(5,1,3),plt.imshow(Exp03),plt.title('Experiment03_momentums')
plt.subplot(5,1,4),plt.imshow(Exp04),plt.
  ↪title('Experiment04_weight_initialization')
plt.subplot(5,1,5),plt.imshow(Exp05),plt.title('Experiment05_Learning_Rates')
```

[ ]:
```
(<Axes: title={'center': 'Experiment05_Learning_Rates'}>,
 <matplotlib.image.AxesImage at 0x7f07a5641c30>,
 Text(0.5, 1.0, 'Experiment05_Learning_Rates'))
```

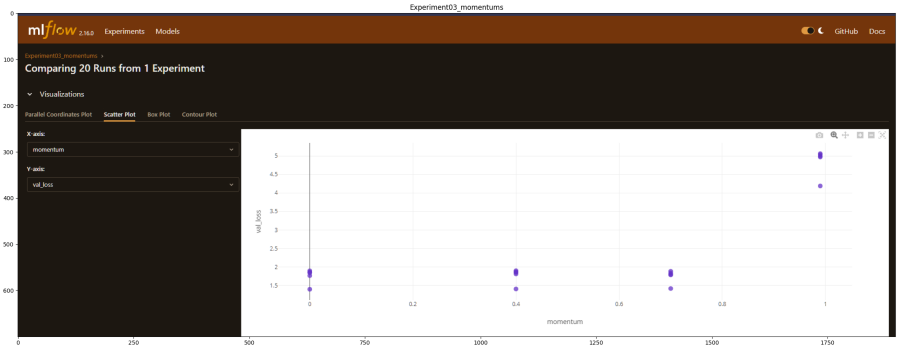
Experiment01_regression_types



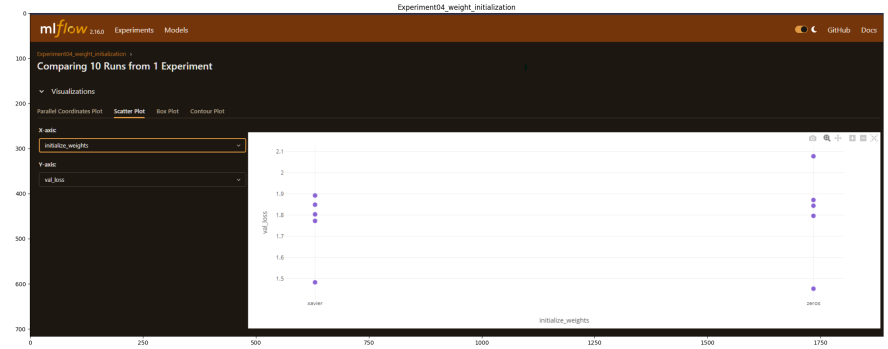
Experiment02_gradeint_calculate_method



Experiment03_momentums



Experiment04_weight_initialization



Experiment05_Learning_Rates