HW3_RegressionV2

April 20, 2020

1 Final Results

- Best Model based on CV scores - Ensemble: XGBoost
- Best Mean Cross Validation Score is 0.8984774624760332
- Best parameters {'learning_rate': 0.1, 'max_depth': 4, 'min_child_weight': 1, 'n_estimators': 192, 'subsample': 0.8}
- Train score is 0.9841860823241139
- Test score is 0.8767229954557099

- Best Model based on Stacking: Voting Top 5
- Best Mean Cross Validation Score is 0.8999858356957512
- Train score is 0.9491284183151113
- Test score is 0.8802582634262037

1.1 Data PreProcessing

[1]:
```
from math import sqrt
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats as stats
from sklearn.metrics import mean_squared_error, r2_score
from math import sqrt
from sklearn.model_selection import GridSearchCV
from sklearn.preprocessing  import PolynomialFeatures
from sklearn.pipeline import make_pipeline
from sklearn.linear_model import LinearRegression
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error, r2_score
from math import sqrt

pd.pandas.set_option('display.max_columns', None)
%matplotlib inline
```

1.1.1 Load Datasets

[2]:
```
# load dataset
# your code here
data = pd.read_csv(r'C:\Users\nabhs\OneDrive\BUAN - Semester 2\BUAN 6341 -␣
↪Applied Machine Learning\Datasets\houseprice.csv')
```

[3]:
```
data.head()
```

[3]:

	Id	MSSubClass	MSZoning	LotFrontage	LotArea	Street	Alley	LotShape
0	1	60	RL	65.0	8450	Pave	NaN	Reg
1	2	20	RL	80.0	9600	Pave	NaN	Reg
2	3	60	RL	68.0	11250	Pave	NaN	IR1
3	4	70	RL	60.0	9550	Pave	NaN	IR1
4	5	60	RL	84.0	14260	Pave	NaN	IR1

	LandContour	Utilities	LotConfig	LandSlope	Neighborhood	Condition1
0	Lvl	AllPub	Inside	Gtl	CollgCr	Norm
1	Lvl	AllPub	FR2	Gtl	Veenker	Feedr
2	Lvl	AllPub	Inside	Gtl	CollgCr	Norm
3	Lvl	AllPub	Corner	Gtl	Crawfor	Norm
4	Lvl	AllPub	FR2	Gtl	NoRidge	Norm

	Condition2	BldgType	HouseStyle	OverallQual	OverallCond	YearBuilt
0	Norm	1Fam	2Story	7	5	2003
1	Norm	1Fam	1Story	6	8	1976
2	Norm	1Fam	2Story	7	5	2001
3	Norm	1Fam	2Story	7	5	1915
4	Norm	1Fam	2Story	8	5	2000

	YearRemodAdd	RoofStyle	RoofMatl	Exterior1st	Exterior2nd	MasVnrType
0	2003	Gable	CompShg	VinylSd	VinylSd	BrkFace
1	1976	Gable	CompShg	MetalSd	MetalSd	None
2	2002	Gable	CompShg	VinylSd	VinylSd	BrkFace
3	1970	Gable	CompShg	Wd Sdng	Wd Shng	None
4	2000	Gable	CompShg	VinylSd	VinylSd	BrkFace

	MasVnrArea	ExterQual	ExterCond	Foundation	BsmtQual	BsmtCond	BsmtExposure
0	196.0	Gd	TA	PConc	Gd	TA	No
1	0.0	TA	TA	CBlock	Gd	TA	Gd
2	162.0	Gd	TA	PConc	Gd	TA	Mn
3	0.0	TA	TA	BrkTil	TA	Gd	No
4	350.0	Gd	TA	PConc	Gd	TA	Av

	BsmtFinType1	BsmtFinSF1	BsmtFinType2	BsmtFinSF2	BsmtUnfSF	TotalBsmtSF
0	GLQ	706	Unf	0	150	856
1	ALQ	978	Unf	0	284	1262

```
2          GLQ         486          Unf           0        434          920
3          ALQ         216          Unf           0        540          756
4          GLQ         655          Unf           0        490         1145

  Heating HeatingQC CentralAir Electrical  1stFlrSF  2ndFlrSF  LowQualFinSF  \
0    GasA        Ex          Y      SBrkr       856       854             0
1    GasA        Ex          Y      SBrkr      1262         0             0
2    GasA        Ex          Y      SBrkr       920       866             0
3    GasA        Gd          Y      SBrkr       961       756             0
4    GasA        Ex          Y      SBrkr      1145      1053             0

   GrLivArea  BsmtFullBath  BsmtHalfBath  FullBath  HalfBath  BedroomAbvGr  \
0       1710             1             0         2         1             3
1       1262             0             1         2         0             3
2       1786             1             0         2         1             3
3       1717             1             0         1         0             3
4       2198             1             0         2         1             4

   KitchenAbvGr KitchenQual  TotRmsAbvGrd Functional  Fireplaces FireplaceQu  \
0             1          Gd             8        Typ           0         NaN
1             1          TA             6        Typ           1          TA
2             1          Gd             6        Typ           1          TA
3             1          Gd             7        Typ           1          Gd
4             1          Gd             9        Typ           1          TA

  GarageType  GarageYrBlt GarageFinish  GarageCars  GarageArea GarageQual  \
0     Attchd       2003.0          RFn           2         548         TA
1     Attchd       1976.0          RFn           2         460         TA
2     Attchd       2001.0          RFn           2         608         TA
3     Detchd       1998.0          Unf           3         642         TA
4     Attchd       2000.0          RFn           3         836         TA

  GarageCond PavedDrive  WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  \
0         TA          Y           0           61              0          0
1         TA          Y         298            0              0          0
2         TA          Y           0           42              0          0
3         TA          Y           0           35            272          0
4         TA          Y         192           84              0          0

   ScreenPorch  PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold  \
0            0         0    NaN   NaN         NaN        0       2    2008
1            0         0    NaN   NaN         NaN        0       5    2007
2            0         0    NaN   NaN         NaN        0       9    2008
3            0         0    NaN   NaN         NaN        0       2    2006
4            0         0    NaN   NaN         NaN        0      12    2008

  SaleType SaleCondition  SalePrice
```

0	WD	Normal	208500
1	WD	Normal	181500
2	WD	Normal	223500
3	WD	Abnorml	140000
4	WD	Normal	250000

1.1.2 Types of variables

[4]:
```
# we have an Id variable, that we should not use for predictions:

print('Number of House Id labels: ', len(data.Id.unique()))
print('Number of Houses in the Dataset: ', len(data))
```

```
Number of House Id labels:  1460
Number of Houses in the Dataset:  1460
```

Find categorical variables

[5]:
```
# find categorical variables- hint data type = 'O'

categorical = [var for var in data.columns if data[var].dtype=='O']

print(f'There are {len(categorical)} categorical variables')
categorical
```

```
There are 43 categorical variables
```

[5]:
```
['MSZoning',
 'Street',
 'Alley',
 'LotShape',
 'LandContour',
 'Utilities',
 'LotConfig',
 'LandSlope',
 'Neighborhood',
 'Condition1',
 'Condition2',
 'BldgType',
 'HouseStyle',
 'RoofStyle',
 'RoofMatl',
 'Exterior1st',
 'Exterior2nd',
 'MasVnrType',
 'ExterQual',
 'ExterCond',
 'Foundation',
```

```
 'BsmtQual',
 'BsmtCond',
 'BsmtExposure',
 'BsmtFinType1',
 'BsmtFinType2',
 'Heating',
 'HeatingQC',
 'CentralAir',
 'Electrical',
 'KitchenQual',
 'Functional',
 'FireplaceQu',
 'GarageType',
 'GarageFinish',
 'GarageQual',
 'GarageCond',
 'PavedDrive',
 'PoolQC',
 'Fence',
 'MiscFeature',
 'SaleType',
 'SaleCondition']
```

Find temporal variables

[6]:
```
# make a list of the numerical variables first= Hint data type != O
numerical = [var for var in data.columns if data[var].dtype!='O']

# list of variables that contain year information= Hint variable namme has Yr␣
 ↪or
year_vars = [var for var in numerical if 'Yr' in var or 'Year' in var]

year_vars
```

[6]:
```
['YearBuilt', 'YearRemodAdd', 'GarageYrBlt', 'YrSold']
```

[7]:
```
numerical
```

[7]:
```
['Id',
 'MSSubClass',
 'LotFrontage',
 'LotArea',
 'OverallQual',
 'OverallCond',
 'YearBuilt',
 'YearRemodAdd',
 'MasVnrArea',
```

```
 'BsmtFinSF1',
 'BsmtFinSF2',
 'BsmtUnfSF',
 'TotalBsmtSF',
 '1stFlrSF',
 '2ndFlrSF',
 'LowQualFinSF',
 'GrLivArea',
 'BsmtFullBath',
 'BsmtHalfBath',
 'FullBath',
 'HalfBath',
 'BedroomAbvGr',
 'KitchenAbvGr',
 'TotRmsAbvGrd',
 'Fireplaces',
 'GarageYrBlt',
 'GarageCars',
 'GarageArea',
 'WoodDeckSF',
 'OpenPorchSF',
 'EnclosedPorch',
 '3SsnPorch',
 'ScreenPorch',
 'PoolArea',
 'MiscVal',
 'MoSold',
 'YrSold',
 'SalePrice']
```

Find discrete variables To identify discrete variables- numerical variables with less than 20 unique values

[8]:
```
# let's visualise the values of the discrete variables
discrete = [var for var in numerical if len(data[var].unique()) < 20 and var␣
 ↪not in year_vars]

print(f'There are {len(discrete)} discrete variables')
discrete
```

```
There are 14 discrete variables
```

[8]:
```
['MSSubClass',
 'OverallQual',
 'OverallCond',
 'BsmtFullBath',
 'BsmtHalfBath',
```

```
 'FullBath',
 'HalfBath',
 'BedroomAbvGr',
 'KitchenAbvGr',
 'TotRmsAbvGrd',
 'Fireplaces',
 'GarageCars',
 'PoolArea',
 'MoSold']
```

Continuous variables

[9]:
```
# find continuous variables- hint numerical variables not in discrete and
 ↪year_years
# Also remove the Id variable and the target variable SalePrice
# which are both also numerical

continuous = [var for var in numerical if var not in discrete and var not in [
    'Id', 'SalePrice'] and var not in year_vars]

print('There are {} numerical and continuous variables'.format(len(numerical)))
continuous
```

```
There are 38 numerical and continuous variables
```

[9]:
```
['LotFrontage',
 'LotArea',
 'MasVnrArea',
 'BsmtFinSF1',
 'BsmtFinSF2',
 'BsmtUnfSF',
 'TotalBsmtSF',
 '1stFlrSF',
 '2ndFlrSF',
 'LowQualFinSF',
 'GrLivArea',
 'GarageArea',
 'WoodDeckSF',
 'OpenPorchSF',
 'EnclosedPorch',
 '3SsnPorch',
 'ScreenPorch',
 'MiscVal']
```

1.1.3 Separate train and test set

[10]:
```
# Let's separate into train and test set
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data.drop(['Id',␣
 ↪'SalePrice'], axis=1),
                                                    data['SalePrice'],
                                                    test_size=0.1,
                                                    random_state=0)

X_train.shape, X_test.shape
```

[10]:
```
((1314, 79), (146, 79))
```

Now we will move on and engineer the features of this dataset. The most important part for this course.

1.1.4 Craete New Variables

Replace 'YearBuilt', 'YearRemodAdd', 'GarageYrBlt with time elapsed since YrSold So YearBuilt = YrSold-YearBuilt.

Similarly transform 'YearRemodAdd', 'GarageYrBlt. After making transformation drop YrSold

[11]:
```
X_train.head()
```

[11]:
```
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
930           20       RL         73.0     8925   Pave   NaN      IR1
656           20       RL         72.0    10007   Pave   NaN      IR1
45           120       RL         61.0     7658   Pave   NaN      Reg
1348          20       RL          NaN    16196   Pave   NaN      IR3
55            20       RL        100.0    10175   Pave   NaN      IR1

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
930          HLS    AllPub    Inside       Gtl       Timber       Norm
656          Lvl    AllPub    Inside       Gtl        NAmes       Norm
45           Lvl    AllPub    Inside       Gtl      NridgHt       Norm
1348         Low    AllPub    Inside       Gtl      SawyerW       Norm
55           Lvl    AllPub    Inside       Gtl        NAmes       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
930        Norm     1Fam     1Story            8            5       2007
656        Norm     1Fam     1Story            5            7       1959
45         Norm   TwnhsE     1Story            9            5       2005
1348       Norm     1Fam     1Story            7            5       1998
55         Norm     1Fam     1Story            6            5       1964

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
930           2007     Gable  CompShg     VinylSd     VinylSd       None
```

```
656           2006     Gable  CompShg     HdBoard     HdBoard    BrkFace
45            2005       Hip  CompShg     MetalSd     MetalSd    BrkFace
1348          1998     Gable  CompShg     VinylSd     VinylSd       None
55            1964     Gable  CompShg     HdBoard     Plywood    BrkFace

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
930          0.0        Gd        TA      PConc       Gd       TA
656         54.0        Gd        TA     CBlock       TA       TA
45         412.0        Ex        TA      PConc       Ex       TA
1348         0.0        Gd        TA      PConc       Gd       TA
55         272.0        TA        TA     CBlock       TA       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
930            Av          GLQ          16          Unf           0
656            No          ALQ         806          Unf           0
45             No          GLQ         456          Unf           0
1348           Gd          GLQ        1443          Unf           0
55             No          BLQ         490          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
930        1450         1466    GasA        Ex          Y      SBrkr
656         247         1053    GasA        Ex          Y      SBrkr
45         1296         1752    GasA        Ex          Y      SBrkr
1348         39         1482    GasA        Ex          Y      SBrkr
55          935         1425    GasA        Gd          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
930       1466         0             0       1466             0             0
656       1053         0             0       1053             1             0
45        1752         0             0       1752             1             0
1348      1494         0             0       1494             1             0
55        1425         0             0       1425             0             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
930          2         0             3             1          Gd
656          1         1             3             1          Gd
45           2         0             2             1          Ex
1348         2         0             3             1          Gd
55           2         0             3             1          TA

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
930              7        Typ           0         NaN     Attchd       2007.0
656              5        Typ           0         NaN     Attchd       1959.0
45               6        Typ           1          Gd     Attchd       2005.0
1348             5        Typ           1          Fa     Attchd       1998.0
55               7        Typ           1          Gd     Attchd       1964.0
```

```
     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
930           Fin           3         610         TA         TA          Y
656           RFn           1         312         TA         TA          Y
45            RFn           2         576         TA         TA          Y
1348          RFn           2         514         TA         TA          Y
55            RFn           2         576         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
930          100           18              0          0            0
656            0            0              0          0            0
45           196           82              0          0            0
1348         402           25              0          0            0
55             0            0              0        407            0

      PoolArea PoolQC  Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
930          0    NaN    NaN         NaN        0       7    2009       WD
656          0    NaN  MnPrv         NaN        0       8    2008       WD
45           0    NaN    NaN         NaN        0       2    2010       WD
1348         0    NaN    NaN         NaN        0       8    2007       WD
55           0    NaN    NaN         NaN        0       7    2008       WD

     SaleCondition
930         Normal
656         Normal
45          Normal
1348        Normal
55          Normal
```

[12]:
```
# function to calculate elapsed time

def elapsed_years(df, var):
    # capture difference between year variable and
    # year the house was sold

    df[var] = df['YrSold'] - df[var]
    return df
```

[13]:
```
for var in ['YearBuilt', 'YearRemodAdd', 'GarageYrBlt']:
    X_train = elapsed_years(X_train, var)
    X_test = elapsed_years(X_test, var)
```

[14]:
```
# drop YrSold
X_train.drop('YrSold', axis=1, inplace=True)
X_test.drop('YrSold', axis=1, inplace=True)
```

[15]:
```
year_vars.remove('YrSold')
```

[16]:
```
# capture the column names for use later in the notebook
final_columns = X_train.columns
final_columns
```

[16]:
```
Index(['MSSubClass', 'MSZoning', 'LotFrontage', 'LotArea', 'Street', 'Alley',
       'LotShape', 'LandContour', 'Utilities', 'LotConfig', 'LandSlope',
       'Neighborhood', 'Condition1', 'Condition2', 'BldgType', 'HouseStyle',
       'OverallQual', 'OverallCond', 'YearBuilt', 'YearRemodAdd', 'RoofStyle',
       'RoofMatl', 'Exterior1st', 'Exterior2nd', 'MasVnrType', 'MasVnrArea',
       'ExterQual', 'ExterCond', 'Foundation', 'BsmtQual', 'BsmtCond',
       'BsmtExposure', 'BsmtFinType1', 'BsmtFinSF1', 'BsmtFinType2',
       'BsmtFinSF2', 'BsmtUnfSF', 'TotalBsmtSF', 'Heating', 'HeatingQC',
       'CentralAir', 'Electrical', '1stFlrSF', '2ndFlrSF', 'LowQualFinSF',
       'GrLivArea', 'BsmtFullBath', 'BsmtHalfBath', 'FullBath', 'HalfBath',
       'BedroomAbvGr', 'KitchenAbvGr', 'KitchenQual', 'TotRmsAbvGrd',
       'Functional', 'Fireplaces', 'FireplaceQu', 'GarageType', 'GarageYrBlt',
       'GarageFinish', 'GarageCars', 'GarageArea', 'GarageQual', 'GarageCond',
       'PavedDrive', 'WoodDeckSF', 'OpenPorchSF', 'EnclosedPorch', '3SsnPorch',
       'ScreenPorch', 'PoolArea', 'PoolQC', 'Fence', 'MiscFeature', 'MiscVal',
       'MoSold', 'SaleType', 'SaleCondition'],
      dtype='object')
```

1.1.5 Feature Engineering Pipeline

[17]:
```
# I will treat discrete variables as if they were categorical
# to treat discrete as categorical using Feature-engine
# we need to re-cast them as object

X_train[discrete] = X_train[discrete].astype('O')
X_test[discrete] = X_test[discrete].astype('O')
```

[18]:
```
# import relevant modules for feature engineering
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from feature_engine import missing_data_imputers as mdi
from feature_engine import categorical_encoders as ce
from feature_engine.variable_transformers import YeoJohnsonTransformer
from sklearn.preprocessing import StandardScaler
from feature_engine.discretisers import DecisionTreeDiscretiser
```

[19]:
```
house_preprocess = Pipeline([

    # missing data imputation
    ('missing_ind', mdi.AddNaNBinaryImputer(
       variables=['LotFrontage', 'MasVnrArea',  'GarageYrBlt'])),
    ('imputer_num', mdi.MeanMedianImputer(imputation_method='mean',
```

```
                                        variables=['LotFrontage',␣
↪'MasVnrArea',  'GarageYrBlt'])),
    ('imputer_cat', mdi.CategoricalVariableImputer(variables=categorical)),

    # categorical encoding
     ('rare_label_enc', ce.RareLabelCategoricalEncoder(
         tol=0.01,n_categories=6, variables=categorical+discrete)),
    ('categorical_enc', ce.MeanCategoricalEncoder(variables = categorical +␣
↪discrete)),

    # Transforming Numerical Variables
    ('yjt', YeoJohnsonTransformer(variables = ['LotFrontage','MasVnrArea',␣
↪'GarageYrBlt'])),


    # discretisation and encoding
    ('treeDisc',  DecisionTreeDiscretiser(cv=2,␣
↪scoring='neg_mean_squared_error',
                                  regression=True,
                                  param_grid={'max_depth': [1,2,3,4,5,6]})),

    # feature Scaling
    ('scaler', StandardScaler()),



])
```

[20]:
```
house_preprocess.fit(X_train,y_train)
```

[20]:
```
Pipeline(memory=None,
         steps=[('missing_ind',
                 AddNaNBinaryImputer(variables=['LotFrontage', 'MasVnrArea',
                                                'GarageYrBlt'])),
                ('imputer_num',
                 MeanMedianImputer(imputation_method='mean',
                                   variables=['LotFrontage', 'MasVnrArea',
                                              'GarageYrBlt'])),
                ('imputer_cat',
                 CategoricalVariableImputer(variables=['MSZoning', 'Street',
                                                       'Alley', 'LotShape',
                                                       'LandContour',
                                                       'Utilities', '…
                                                    'Utilities', 'LotConfig',
                                                    'LandSlope', 'Neighborhood',
                                                    'Condition1', 'Condition2',
                                                    'BldgType', 'HouseStyle',
```

```
                                                    'OverallQual',
                                                    'OverallCond', 'YearBuilt',
                                                    'YearRemodAdd', 'RoofStyle',
                                                    'RoofMatl', 'Exterior1st',
                                                    'Exterior2nd', 'MasVnrType',
                                                    'MasVnrArea', 'ExterQual',
                                                    'ExterCond', 'Foundation',
                                                    'BsmtQual', …])),
                ('scaler',
                 StandardScaler(copy=True, with_mean=True, with_std=True))],
          verbose=False)
```

[21]:
```
# Apply Transformations
X_train=house_preprocess.transform(X_train)
X_test=house_preprocess.transform(X_test)
```

1.2 DO NOT CHANGE STEPS BEFORE THIS POINT

1.3 Simple Models

1.3.1 Linear Regression

[22]:
```
# Train a linear regression model, report the coefficients and model␣
 ↪performance

from sklearn.linear_model import LinearRegression
from sklearn.model_selection import cross_val_score

lr = LinearRegression().fit(X_train, y_train)
cv_scores = cross_val_score(lr, X_train, y_train)
```

Results

[23]:
```
x_lrtrain= lr.predict(X_train)
x_lrtest = lr.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_lrtrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_lrtrain))))
print('train r2: {}'.format(r2_score(y_train, x_lrtrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_lrtest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_lrtest))))
print('test r2: {}'.format(r2_score(y_test, x_lrtest)))

#print("Best parameters: {}".format(lr.best_params_))
print("Mean Cross-validation scores: {}".format(cv_scores))
```

```
print('Train score: {:.4f}'.format(lr.score(X_train, y_train)))
print('Test score: {:.4f}'.format(lr.score(X_test, y_test)))
```

```
train mse: 552937051.405446
train rmse: 23514.61357125492
train r2: 0.9114426745730106

test mse: 861097775.8563162
test rmse: 29344.467551078793
test r2: 0.8746968378820517
Mean Cross-validation scores: [ 8.68312903e-01 -6.26561684e+21  8.76203279e-01
8.98626806e-01
  8.92290590e-01]
Train score: 0.9114
Test score: 0.8747
```

1.3.2 Ridge Regression

[24]:
```
# Train a Ridge regression model, report the coefficients, the best parameters,␣
↪and model performance
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import Ridge
ridge = Ridge()

#define a list of parameters
#param_ridge = {'alpha':[0.001, 0.01, 0.1, 1, 10, 100] }
param_ridge = {'alpha':[1, 1e3, 1e4] }
grid_ridge = GridSearchCV(ridge, param_ridge, cv=10, return_train_score =␣
↪True,scoring='r2')
grid_ridge.fit(X_train, y_train)
```

[24]:
```
GridSearchCV(cv=10, error_score=nan,
             estimator=Ridge(alpha=1.0, copy_X=True, fit_intercept=True,
                             max_iter=None, normalize=False, random_state=None,
                             solver='auto', tol=0.001),
             iid='deprecated', n_jobs=None,
             param_grid={'alpha': [1, 1000.0, 10000.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='r2', verbose=0)
```

Results

[25]:
```
x_gridtrain= grid_ridge.predict(X_train)
x_gridtest = grid_ridge.predict(X_test)

# check model performance:
```

```
print('train mse: {}'.format(mean_squared_error(y_train, x_gridtrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_gridtrain))))
print('train r2: {}'.format(r2_score(y_train, x_gridtrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_gridtest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_gridtest))))
print('test r2: {}'.format(r2_score(y_test, x_gridtest)))

print("Best parameters: {}".format(grid_ridge.best_params_))
print("Cross-validation scores: {}".format(grid_ridge.best_score_))
print('Train score: {:.4f}'.format(grid_ridge.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_ridge.score(X_test, y_test)))
```

```
train mse: 552540520.7585117
train rmse: 23506.1804800038
train r2: 0.911506182152134

test mse: 858035459.791463
test rmse: 29292.242314159957
test r2: 0.8751424526508844
Best parameters: {'alpha': 1}
Cross-validation scores: 0.8843424460850325
Train score: 0.9115
Test score: 0.8751
```

1.3.3 Lasso

[26]:
```
# Train a Lasso regression model, report the coefficients, the best parameters,␣
 ↪and model performance

# YOUR CODE HERE

from sklearn.linear_model import Lasso
lasso = Lasso(random_state=0)

#define a list of parameters
#param_lasso = {'alpha':[0.001, 0.01, 0.1, 1, 10, 100] }
param_lasso = {'alpha':[1, 1e4, 1e5] }

grid_lasso = GridSearchCV(lasso, param_lasso, cv=10, return_train_score =␣
 ↪True,scoring='r2')
grid_lasso.fit(X_train, y_train)
```

[26]:
```
GridSearchCV(cv=10, error_score=nan,
             estimator=Lasso(alpha=1.0, copy_X=True, fit_intercept=True,
                             max_iter=1000, normalize=False, positive=False,
                             precompute=False, random_state=0,
```

```
                        selection='cyclic', tol=0.0001, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'alpha': [1, 10000.0, 100000.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='r2', verbose=0)
```

Results

[27]:
```
x_lassotrain= grid_lasso.predict(X_train)
x_lassotest = grid_lasso.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_lassotrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_lassotrain))))
print('train r2: {}'.format(r2_score(y_train, x_lassotrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_lassotest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_lassotest))))
print('test r2: {}'.format(r2_score(y_test, x_lassotest)))

print("Best parameters: {}".format(grid_lasso.best_params_))
print("Cross-validation scores: {}".format(grid_lasso.best_score_))
print('Train score: {:.4f}'.format(grid_lasso.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_lasso.score(X_test, y_test)))
```

```
train mse: 552539222.3512008
train rmse: 23506.152861563733
train r2: 0.9115063901025299

test mse: 857849072.1153543
test rmse: 29289.060621934503
test r2: 0.87516957496597
Best parameters: {'alpha': 1}
Cross-validation scores: 0.8843049751400216
Train score: 0.9115
Test score: 0.8752
```

1.4 Linear Regression with SGD

[28]:
```
from sklearn.linear_model import SGDRegressor
```

[29]:
```
# create pipeline
reg_sgd_pipe = Pipeline([

    # feature Scaling
    ('scaler', MinMaxScaler()),
```

```
    # regression
    ('sgd_reg', SGDRegressor(max_iter=1000, tol = 1e-6))
])

param_sgd = {'sgd_reg__eta0':[0.01, 0.05, 0.1 ,0.5],
             'sgd_reg__penalty' :['l1','l2'],#lasso,ridge
             'sgd_reg__alpha' :[0.1,0.01,0.001] }

grid_linearsgd = GridSearchCV(reg_sgd_pipe,
                              param_sgd,cv=5,
                              n_jobs=-1,
                              return_train_score = True,
                              scoring='r2')

# let's fit the pipeline
grid_linearsgd.fit(X_train, y_train)

# let's get the predictions
X_train_preds = grid_linearsgd.predict(X_train)
X_test_preds = grid_linearsgd.predict(X_test)
```

1.4.1 Results

[30]:
```
# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, X_train_preds)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, X_train_preds))))
print('train r2: {}'.format(r2_score(y_train, X_train_preds)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, X_test_preds)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, X_test_preds))))
print('test r2: {}'.format(r2_score(y_test, X_test_preds)))

print("Best parameters: {}".format(grid_linearsgd.best_params_))
print('Train score: {:.4f}'.format(grid_linearsgd.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_linearsgd.score(X_test, y_test)))
```

```
train mse: 594505167.346368
train rmse: 24382.476645049166
train r2: 0.9047852057681796

test mse: 957543094.9385668
test rmse: 30944.19323457257
test r2: 0.8606625391167776
Best parameters: {'sgd_reg__alpha': 0.01, 'sgd_reg__eta0': 0.05,
'sgd_reg__penalty': 'l1'}
Train score: 0.9048
```

```
Test score: 0.8607
```

1.5 Polynomial Regression

[31]:
```
#apply polynomial regression in pipeline
#pipe_poly = make_pipeline(PolynomialFeatures(),MinMaxScaler(),␣
 ↪LinearRegression())
pipe_poly=Pipeline([
    ('polynomialfeatures', PolynomialFeatures()),
    ('scaler',MinMaxScaler()),
    ('norm_reg', LinearRegression())

])
#define a list of parameters
param_poly = {'polynomialfeatures__degree':range(1,3)}

grid_poly = GridSearchCV(pipe_poly, param_poly,cv=5, n_jobs=-1,␣
 ↪return_train_score = True,scoring='r2')


grid_poly.fit(X_train, y_train)

# let's get the predictions
X_train_preds = grid_poly.predict(X_train)
X_test_preds = grid_poly.predict(X_test)
```

1.5.1 Results

[32]:
```
x_polytrain= grid_lasso.predict(X_train)
x_polytest = grid_lasso.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_polytrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_polytrain))))
print('train r2: {}'.format(r2_score(y_train, x_polytrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_polytest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_polytest))))
print('test r2: {}'.format(r2_score(y_test, x_polytest)))

print("Best parameters: {}".format(grid_poly.best_params_))
print("Cross-validation scores: {}".format(grid_poly.best_score_))
print('Train score: {:.4f}'.format(grid_poly.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_poly.score(X_test, y_test)))
```

```
train mse: 552539222.3512008
```

```
train rmse: 23506.152861563733
train r2: 0.9115063901025299

test mse: 857849072.1153543
test rmse: 29289.060621934503
test r2: 0.87516957496597
Best parameters: {'polynomialfeatures__degree': 2}
Cross-validation scores: -9.790048692779738e+22
Train score: 1.0000
Test score: -312603571663290826752.0000
```

[33]:
```
print('train mse: {}'.format(mean_squared_error(y_train, X_train_preds)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, X_train_preds))))
print('train r2: {}'.format(r2_score(y_train, X_train_preds)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, X_test_preds)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, X_test_preds))))
print('test r2: {}'.format(r2_score(y_test, X_test_preds)))
```

```
train mse: 27597.318873668188
train rmse: 166.12440782036873
train r2: 0.9999955800669494

test mse: 2.1482477834886397e+30
test rmse: 1465690207202272.2
test r2: -3.126035716632908e+20
```

1.6 ElasticNet

[34]:
```
from sklearn.linear_model import ElasticNet

elasticnet = ElasticNet().fit(X_train, y_train)

#define a list of parameters
param_elasticnet = {'alpha':[1, 1e4, 1e5],
                    'l1_ratio' :[0.2,0.4,0.6,0.8]}

grid_elasticnet = GridSearchCV(elasticnet , param_elasticnet, cv=5,␣
 ↪return_train_score = True,scoring='r2')
grid_elasticnet.fit(X_train, y_train)

x_elastictrain_predict = grid_elasticnet.predict(X_train)
x_elastictest_predict = grid_elasticnet.predict(X_test)
```

1.6.1 Results

[35]:
```
print('train mse: {}'.format(mean_squared_error(y_train,␣
 ↪x_elastictrain_predict)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_elastictrain_predict))))
print('train r2: {}'.format(r2_score(y_train, x_elastictrain_predict)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_elastictest_predict)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test,␣
 ↪x_elastictest_predict))))
print('test r2: {}'.format(r2_score(y_test, x_elastictest_predict)))
print()
print('Best parameters: ', grid_elasticnet.best_params_)
print('Best cross-validation score:', grid_elasticnet.score(X_test, y_test))
print("Training set score: {:.2f}".format(grid_elasticnet.score(X_train,␣
 ↪y_train)))
print("Test set score: {:.2f}".format(grid_elasticnet.score(X_test, y_test)))
```

```
train mse: 580812656.1496782
train rmse: 24100.055106776796
train r2: 0.9069781717972707

test mse: 908630644.7418916
test rmse: 30143.500870699998
test r2: 0.8677800638026185

Best parameters:  {'alpha': 1, 'l1_ratio': 0.8}
Best cross-validation score: 0.8677800638026185
Training set score: 0.91
Test set score: 0.87
```

1.7 Tune Multiple Models with one GridSearch

1.7.1 Model - Linear Regression with Model Parameter - Ridge *GridSearch

[36]:
```
model_linear = Pipeline([("regressor", LinearRegression())] )
```

[37]:
```
model_parm_gd1 = [{ 'regressor': [Ridge()]}]
```

[38]:
```
from sklearn import svm
grid_search_linear = GridSearchCV(svm.SVC(gamma='auto'),{
    'C':[30],
    'kernel':['linear']

},cv=5,return_train_score=False,scoring='r2')
```

[39]:
```
grid_search_linear = GridSearchCV(model_linear,model_parm_gd1,scoring='r2')
```

[40]:
```
grid_search_linear.fit(X_train,y_train)
```

[40]:
```
GridSearchCV(cv=None, error_score=nan,
             estimator=Pipeline(memory=None,
                                steps=[('regressor',
                                        LinearRegression(copy_X=True,
                                                         fit_intercept=True,
                                                         n_jobs=None,
                                                         normalize=False))],
                                verbose=False),
             iid='deprecated', n_jobs=None,
             param_grid=[{'regressor': [Ridge(alpha=1.0, copy_X=True,
                                              fit_intercept=True, max_iter=None,
                                              normalize=False,
                                              random_state=None, solver='auto',
                                              tol=0.001)]}],
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='r2', verbose=0)
```

Results

[41]:
```
x_lrtrain= grid_search_linear.predict(X_train)
x_lrtest = grid_search_linear.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_lrtrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_lrtrain))))
print('train r2: {}'.format(r2_score(y_train, x_lrtrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_lrtest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_lrtest))))
print('test r2: {}'.format(r2_score(y_test, x_lrtest)))
print()

print("Best parameters: {}".format(grid_search_linear.best_params_))
print("Cross-validation scores: {}".format(grid_search_linear.best_score_))
print('Train score: {:.4f}'.format(grid_search_linear.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_search_linear.score(X_test, y_test)))
```

```
train mse: 552540520.7585117
train rmse: 23506.1804800038
train r2: 0.911506182152134

test mse: 858035459.791463
test rmse: 29292.242314159957
test r2: 0.8751424526508844
```

```
Best parameters: {'regressor': Ridge(alpha=1.0, copy_X=True, fit_intercept=True,
max_iter=None,
      normalize=False, random_state=None, solver='auto', tol=0.001)}
Cross-validation scores: 0.8818969790895617
Train score: 0.9115
Test score: 0.8751
```

1.8 Linear Regression with Model Parameter - Lasso *GridSearchCV

[42]:
```
model_linear2 = Pipeline([("regressor", LinearRegression())] )
```

[43]:
```
model_parm_gd2 = [{ 'regressor': [Lasso(random_state=0)]}]
```

[44]:
```
grid_search_linear2 = GridSearchCV(svm.SVC(gamma='auto'),{
    'C':[1,10,20,30],
    'kernel':['polynomial']

},cv=5,return_train_score=False,scoring='r2')
```

[45]:
```
grid_search_linear2 = GridSearchCV(model_linear2,model_parm_gd2,scoring='r2')
```

[46]:
```
grid_search_linear2.fit(X_train,y_train)
```

[46]:
```
GridSearchCV(cv=None, error_score=nan,
             estimator=Pipeline(memory=None,
                                steps=[('regressor',
                                        LinearRegression(copy_X=True,
                                                         fit_intercept=True,
                                                         n_jobs=None,
                                                         normalize=False))],
                                verbose=False),
             iid='deprecated', n_jobs=None,
             param_grid=[{'regressor': [Lasso(alpha=1.0, copy_X=True,
                                              fit_intercept=True, max_iter=1000,
                                              normalize=False, positive=False,
                                              precompute=False, random_state=0,
                                              selection='cyclic', tol=0.0001,
                                              warm_start=False)]}],
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='r2', verbose=0)
```

Results

[47]:
```
x_lrtrain= grid_search_linear2.predict(X_train)
x_lrtest = grid_search_linear2.predict(X_test)

# check model performance:
```

```
print('train mse: {}'.format(mean_squared_error(y_train, x_lrtrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_lrtrain))))
print('train r2: {}'.format(r2_score(y_train, x_lrtrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_lrtest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_lrtest))))
print('test r2: {}'.format(r2_score(y_test, x_lrtest)))
print()
print("Best parameters: {}".format(grid_search_linear2.best_params_))
print("Cross-validation scores: {}".format(grid_search_linear2.best_score_))
print('Train score: {:.4f}'.format(grid_search_linear2.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_search_linear2.score(X_test, y_test)))
```

```
train mse: 552539222.3512008
train rmse: 23506.152861563733
train r2: 0.9115063901025299

test mse: 857849072.1153543
test rmse: 29289.060621934503
test r2: 0.87516957496597

Best parameters: {'regressor': Lasso(alpha=1.0, copy_X=True, fit_intercept=True,
max_iter=1000,
      normalize=False, positive=False, precompute=False, random_state=0,
      selection='cyclic', tol=0.0001, warm_start=False)}
Cross-validation scores: 0.881849542095595
Train score: 0.9115
Test score: 0.8752
```

1.9 Pipeline - RandomForest Regressor with Model Parameter - Linear Regression *GridSearchCV

[48]:
```
from sklearn.ensemble import RandomForestRegressor
```

[49]:
```
model_rf = Pipeline([('regressor', RandomForestRegressor(random_state = 42))])
```

[50]:
```
model_parm_rf = [{ 'regressor': [LinearRegression()]}]
```

[51]:
```
from sklearn import svm
```

[52]:
```
grid_rf = GridSearchCV(svm.SVC(gamma='auto'),{
    'C':[30],
    'kernel':['linear']

},cv=5,return_train_score=False,scoring='r2')
```

[53]:
```
grid_rf = GridSearchCV(model_rf, model_parm_rf)
```

[54]:
```
grid_rf.fit(X_train,y_train)
```

[54]:
```
GridSearchCV(cv=None, error_score=nan,
             estimator=Pipeline(memory=None,
                                steps=[('regressor',
                                        RandomForestRegressor(bootstrap=True,
                                                              ccp_alpha=0.0,
                                                              criterion='mse',
                                                              max_depth=None,
max_features='auto',
max_leaf_nodes=None,
                                                              max_samples=None,
min_impurity_decrease=0.0,
min_impurity_split=None,
min_samples_leaf=1,
min_samples_split=2,
min_weight_fraction_leaf=0.0,
                                                              n_estimators=100,
                                                              n_jobs=None,
                                                              oob_score=False,
                                                              random_state=42,
                                                              verbose=0,
warm_start=False))],
                                verbose=False),
             iid='deprecated', n_jobs=None,
             param_grid=[{'regressor': [LinearRegression(copy_X=True,
                                                         fit_intercept=True,
                                                         n_jobs=None,
                                                         normalize=False)]}],
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

1.9.1 Results

[55]:
```
x_rftrain= grid_rf.predict(X_train)
x_rftest = grid_rf.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_rftrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_rftrain))))
print('train r2: {}'.format(r2_score(y_train, x_rftrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_rftest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_rftest))))
print('test r2: {}'.format(r2_score(y_test, x_rftest)))
```

```
print("Best parameters: {}".format(grid_rf.best_params_))
print("Cross-validation scores: {}".format(grid_rf.best_score_))
print('Train score: {:.4f}'.format(grid_rf.score(X_train, y_train)))
print('Test score: {:.4f}'.format(grid_rf.score(X_test, y_test)))
```

```
train mse: 552937051.405446
train rmse: 23514.61357125492
train r2: 0.9114426745730106

test mse: 861097775.8563162
test rmse: 29344.467551078793
test r2: 0.8746968378820517
Best parameters: {'regressor': LinearRegression(copy_X=True, fit_intercept=True,
n_jobs=None, normalize=False)}
Cross-validation scores: -1.2531233677405604e+21
Train score: 0.9114
Test score: 0.8747
```

1.10 KNN Regressor

[56]:
```
from sklearn.neighbors import KNeighborsRegressor
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import MinMaxScaler
knnreg = KNeighborsRegressor().fit(X_train, y_train)
print("Training set score: {:.2f}".format(knnreg.score(X_train, y_train)))
print("Test set score: {:.2f}".format(knnreg.score(X_test, y_test)))
```

```
Training set score: 0.88
Test set score: 0.59
```

[57]:
```
pipe_knn = make_pipeline(MinMaxScaler(), KNeighborsRegressor())
knnreg = pipe_knn.fit(X_train, y_train)
print("Training set score: {:.2f}".format(knnreg.score(X_train, y_train)))
print("Test set score: {:.2f}".format(knnreg.score(X_test, y_test)))
```

```
Training set score: 0.86
Test set score: 0.71
```

[58]:
```
    from sklearn.model_selection import GridSearchCV

    pipe_knn=Pipeline([
        ('scaler',MinMaxScaler()),
        ('knnreg', KNeighborsRegressor())

    ])
    # define a list of parameters
    #param_knn = {'n_neighbors': [5, 10, 15, 20, 25, 30]}
```

```
    param_knn = {'knnreg__n_neighbors': range(1,25)}

    #apply grid search
    grid_knn = GridSearchCV(pipe_knn, param_knn, cv=5,␣
↪return_train_score=True,scoring='r2')
    grid_knn.fit(X_train, y_train)
```

[58]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=Pipeline(memory=None,
                                steps=[('scaler',
                                        MinMaxScaler(copy=True,
                                                     feature_range=(0, 1))),
                                       ('knnreg',
                                        KNeighborsRegressor(algorithm='auto',
                                                            leaf_size=30,
                                                            metric='minkowski',
                                                            metric_params=None,
                                                            n_jobs=None,
                                                            n_neighbors=5, p=2,
weights='uniform'))],
                                verbose=False),
             iid='deprecated', n_jobs=None,
             param_grid={'knnreg__n_neighbors': range(1, 25)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring='r2', verbose=0)
```

1.10.1 Results

[59]:
```
x_knntrain= grid_knn.predict(X_train)
x_knntest = grid_knn.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_knntrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_knntrain))))
print('train r2: {}'.format(r2_score(y_train, x_knntrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_knntest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_knntest))))
print('test r2: {}'.format(r2_score(y_test, x_knntest)))
print()
print('train score: ', grid_knn.score(X_train, y_train))
print('test score: ', grid_knn.score(X_test, y_test))

#find best parameters
print('Best parameters: ', grid_knn.best_params_)
print('Best cross-validation score:', grid_knn.best_score_)
```

```
train mse: 926540858.0310757
train rmse: 30439.13366098115
train r2: 0.8516070137143069

test mse: 1657648286.6700912
test rmse: 40714.227079364915
test r2: 0.7587863099604379

train score:  0.8516070137143069
test score:  0.7587863099604379
Best parameters:  {'knnreg__n_neighbors': 6}
Best cross-validation score: 0.78587417331835
```

1.11 ElasticNet with GridSearch

[60]:
```
elasticnet = ElasticNet()

#define a list of parameters
param_elasticnet = {'alpha':[0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10],␣
 ↪'l1_ratio' :[0.2,0.4,0.6,0.8]}

grid_elasticnet = GridSearchCV(elasticnet , param_elasticnet, cv=5,␣
 ↪return_train_score = True,scoring='r2')
grid_elasticnet.fit(X_train, y_train)

grid_elasticnet_train_score = grid_elasticnet.score(X_train, y_train)
grid_elasticnet_test_score = grid_elasticnet.score(X_test, y_test)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 275261918430.7595, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270472843507.742, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269415475236.1935, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 293367949607.249, tolerance: 642749145.1567798
  positive)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299702168310.0032, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 275132322643.92615, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270265546612.78378, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269359988115.02875, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 293114639456.2878, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299461621874.3815, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274876218400.22867, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269853488069.79288, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269250900786.1243, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
```

```
Duality gap: 292610782725.36975, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 298983659623.677, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274113520713.21634, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 268620977582.17148, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 268927308309.11826, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 291102803101.93744, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 297554322499.26166, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 275285371342.0834, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270500219669.26224, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269455263299.4938, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
```

```
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 293390700602.9906, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299724423882.7319, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 275126170208.67175, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270267583340.30392, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269382447458.56412, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 293109101936.22723, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299452447939.0266, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274841772404.84204, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269830678356.61826, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269256329279.5095, tolerance: 635955900.9288123
```

```
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 292577554374.5457, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 298943887810.3167, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274051946790.85733, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 268573717281.67993, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 268915978578.34824, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 291042350452.3709, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 297484634292.5844, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274840164312.18774, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270621725492.51758, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
```

```
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269731153808.08066, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 293432778873.37506, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299665315171.12964, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 274320207459.15918, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 270089455409.16162, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269461868093.74542, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 292811730158.3288, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 299004317909.24976, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 273940590197.94852, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269428587209.82605, tolerance: 655974723.0327224
  positive)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 269193156672.4067, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 292033002979.416, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 298242533193.7177, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 273151756027.88977, tolerance: 657118734.8147435
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 267998525106.42767, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 268738473819.79742, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 290312550120.06335, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 296613343354.8944, tolerance: 689033704.679551
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 221086170647.84283, tolerance: 655974723.0327224
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
```

```
Duality gap: 204650042677.63684, tolerance: 635955900.9288123
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 232586340970.15808, tolerance: 642749145.1567798
  positive)
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\linear_model\_coordinate_descent.py:476: ConvergenceWarning:
Objective did not converge. You might want to increase the number of iterations.
Duality gap: 186705495812.65787, tolerance: 689033704.679551
  positive)
```

1.11.1 Results

[61]:
```
# let's get the predictions
x_elastictrain= grid_elasticnet.predict(X_train)
x_elastictest = grid_elasticnet.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_elastictrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_elastictrain))))
print('train r2: {}'.format(r2_score(y_train, x_elastictrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_elastictest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_elastictest))))
print('test r2: {}'.format(r2_score(y_test, x_elastictest)))

print('Training set score: ', grid_elasticnet_train_score)
print('Test score: ', grid_elasticnet_test_score)

#find best parameters
print('Best parameters: ', grid_elasticnet.best_params_)
print('Best cross-validation score:', grid_elasticnet.best_score_)
```

```
train mse: 560460520.2398213
train rmse: 23674.04739878294
train r2: 0.9102377304004107

test mse: 872749277.5992303
test rmse: 29542.33026691074
test r2: 0.8730013625797748
Training set score:  0.9102377304004107
Test score:  0.8730013625797748
Best parameters:  {'alpha': 0.1, 'l1_ratio': 0.2}
Best cross-validation score: 0.8840700291378194
```

1.12 Decision Tree Regression

[62]:
```
from sklearn.tree import DecisionTreeRegressor
from sklearn.model_selection import GridSearchCV
decisiontree = DecisionTreeRegressor(random_state = 0)


param_DTree = {"max_depth": range(1,30),
               "max_leaf_nodes": range(2,20),
              "min_samples_split":range(2,30)}

grid_dtree = GridSearchCV(decisiontree,param_DTree,cv=5,scoring='r2')
grid_dtree.fit(X_train,y_train)
```

[62]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=DecisionTreeRegressor(ccp_alpha=0.0, criterion='mse',
                                             max_depth=None, max_features=None,
                                             max_leaf_nodes=None,
                                             min_impurity_decrease=0.0,
                                             min_impurity_split=None,
                                             min_samples_leaf=1,
                                             min_samples_split=2,
                                             min_weight_fraction_leaf=0.0,
                                             presort='deprecated',
                                             random_state=0, splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'max_depth': range(1, 30),
                         'max_leaf_nodes': range(2, 20),
                         'min_samples_split': range(2, 30)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='r2', verbose=0)
```

1.12.1 Results

[63]:
```
# let's get the predictions
x_dtreetrain= grid_dtree.predict(X_train)
x_dtreetest = grid_dtree.predict(X_test)

print('train mse: {}'.format(mean_squared_error(y_train, x_dtreetrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_dtreetrain))))
print('train r2: {}'.format(r2_score(y_train, x_dtreetrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_dtreetest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_dtreetest))))
print('test r2: {}'.format(r2_score(y_test, x_dtreetest)))
print()
print('Best parameters: ', grid_dtree.best_params_)
```

```
print("Accuracy on training set: {:.4f}".format(grid_dtree.score(X_train,␣
 ↪y_train)))
print("Accuracy on test set: {:.3f}".format(grid_dtree.score(X_test, y_test)))
```

```
train mse: 1105977258.816959
train rmse: 33256.23638984061
train r2: 0.8228688278802175

test mse: 1548654925.2624905
test rmse: 39352.953196202325
test r2: 0.7746465446714791

Best parameters:  {'max_depth': 6, 'max_leaf_nodes': 19, 'min_samples_split':
29}
Accuracy on training set: 0.8229
Accuracy on test set: 0.775
```

1.13 SVM

[64]:
```
from sklearn.svm import SVC
svc_kernel = SVC()

#define a list of parameters
param_svc_kernel = [{'C': [1,10,100,1000,10000],
                     'gamma':['auto'],
                    'kernel':['rbf']},
                     {'C': [1,10,100,1000,10000],
                     'gamma':['auto'],
                    'kernel':['poly']},
                     {'C': [1,10,100,1000,10000],
                     'gamma':['auto'],
                    'kernel':['sigmoid',]}]


#apply grid search
grid_svc_kernel = GridSearchCV(svc_kernel, param_svc_kernel, cv=5,␣
 ↪n_jobs=2,scoring='r2')
grid_svc_kernel.fit(X_train, y_train)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\model_selection\_split.py:667: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  % (min_groups, self.n_splits)), UserWarning)
```

[64]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=SVC(C=1.0, break_ties=False, cache_size=200,
                           class_weight=None, coef0=0.0,
```

```
                    decision_function_shape='ovr', degree=3,
                    gamma='scale', kernel='rbf', max_iter=-1,
                    probability=False, random_state=None, shrinking=True,
                    tol=0.001, verbose=False),
             iid='deprecated', n_jobs=2,
             param_grid=[{'C': [1, 10, 100, 1000, 10000], 'gamma': ['auto'],
                          'kernel': ['rbf']},
                         {'C': [1, 10, 100, 1000, 10000], 'gamma': ['auto'],
                          'kernel': ['poly']},
                         {'C': [1, 10, 100, 1000, 10000], 'gamma': ['auto'],
                          'kernel': ['sigmoid']}],
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='r2', verbose=0)
```

1.13.1 Results

[65]:
```
# let's get the predictions
x_svctrain= grid_svc_kernel.predict(X_train)
x_svctest = grid_svc_kernel.predict(X_test)

print('train mse: {}'.format(mean_squared_error(y_train, x_svctrain)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_svctrain))))
print('train r2: {}'.format(r2_score(y_train, x_svctrain)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_svctest)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_svctest))))
print('test r2: {}'.format(r2_score(y_test, x_svctest)))
print()
print('Best parameters: ', grid_svc_kernel.best_params_)
print('train score: ', grid_svc_kernel.score(X_train, y_train))
print('test score: ', grid_svc_kernel.score(X_train, y_train))
```

```
train mse: 61834.09436834094
train rmse: 248.66462226931466
train r2: 0.9999900967714073

test mse: 1296973682.7054794
test rmse: 36013.520831841466
test r2: 0.8112700924524573

Best parameters:  {'C': 100, 'gamma': 'auto', 'kernel': 'poly'}
train score:  0.9999900967714073
test score:  0.9999900967714073
```

2 Ensemble

2.1 Bagging

2.1.1 With Descision Tree Regressor

[66]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import BaggingRegressor
```

[67]:
```
bag_dtree1 = BaggingRegressor(base_estimator=DecisionTreeRegressor(),␣
↪bootstrap=True, random_state=0, oob_score=True)

bag_dtree1_param = {
                 'base_estimator__max_depth': range(1,10),
                 'max_samples':  [0.8,1],
                 'n_estimators': range(1,80,5)}
bag_dtree1_grid = GridSearchCV(bag_dtree1, bag_dtree1_param,cv=5,␣
↪return_train_score=True)
bag_dtree1_grid.fit(X_train,y_train)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
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packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
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reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
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OOB scores. This probably means too few estimators were used to compute any
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C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
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OOB scores. This probably means too few estimators were used to compute any
```

```
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
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reliable oob estimates.
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C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
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OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
```

```
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
```

[67]:
```
GridSearchCV(cv=5, error_score=nan,
estimator=BaggingRegressor(base_estimator=DecisionTreeRegressor(ccp_alpha=0.0,
criterion='mse',
max_depth=None,
max_features=None,
max_leaf_nodes=None,
min_impurity_decrease=0.0,
min_impurity_split=None,
min_samples_leaf=1,
min_samples_split=2,
min_weight_fraction_leaf=0.0,
presort='deprecated',
random_state=None,
splitter='be…
                                    bootstrap_features=False,
                                    max_features=1.0, max_samples=1.0,
                                    n_estimators=10, n_jobs=None,
                                    oob_score=True, random_state=0,
                                    verbose=0, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'base_estimator__max_depth': range(1, 10),
                         'max_samples': [0.8, 1],
                         'n_estimators': range(1, 80, 5)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

Results

[68]:
```
# let's get the predictions
x_bagtree_train= bag_dtree1_grid.predict(X_train)
x_bagtree_test = bag_dtree1_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_bagtree_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_bagtree_train))))
print('train r2: {}'.format(r2_score(y_train, x_bagtree_train)))
```

```
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_bagtree_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_bagtree_test))))
print('test r2: {}'.format(r2_score(y_test, x_bagtree_test)))
print()
print(f'Best Mean Cross Validation Score is {bag_dtree1_grid.best_score_}')
print(f'Best parameters {bag_dtree1_grid.best_params_}')
print(f'Train score is {bag_dtree1_grid.score(X_train,y_train)}')
print(f'Test score is {bag_dtree1_grid.score(X_test,y_test)}')
```

```
train mse: 238564809.90829495
train rmse: 15445.543367207738
train r2: 0.9617919228729973

test mse: 982627004.5486312
test rmse: 31346.881895152364
test r2: 0.8570124388836232

Best Mean Cross Validation Score is 0.8701118447613622
Best parameters {'base_estimator__max_depth': 9, 'max_samples': 0.8,
'n_estimators': 61}
Train score is 0.9617919228729972
Test score is 0.8570124388836233
```

2.1.2 With HW2 Best Model - Lasso

[69]:
```
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import Lasso
```

[70]:
```
bag_lasso = BaggingRegressor(base_estimator=Lasso(), bootstrap=True,␣
↪random_state=0, oob_score=True)

bag_lasso_param = {'base_estimator__alpha': [1, 1e4, 1e5]}

bag_lasso_grid = GridSearchCV(bag_lasso, bag_lasso_param,cv=5,␣
↪return_train_score=True)
bag_lasso_grid.fit(X_train,y_train)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
```

```
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
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OOB scores. This probably means too few estimators were used to compute any
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reliable oob estimates.
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C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
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C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
```

```
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packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
```

[70]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=BaggingRegressor(base_estimator=Lasso(alpha=1.0,
                                                              copy_X=True,
                                                              fit_intercept=True,
                                                              max_iter=1000,
                                                              normalize=False,
                                                              positive=False,
                                                              precompute=False,
                                                              random_state=None,
                                                              selection='cyclic',
                                                              tol=0.0001,
                                                              warm_start=False),
                                        bootstrap=True,
                                        bootstrap_features=False,
                                        max_features=1.0, max_samples=1.0,
                                        n_estimators=10, n_jobs=None,
                                        oob_score=True, random_state=0,
                                        verbose=0, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'base_estimator__alpha': [1, 10000.0, 100000.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

Results

[71]:
```
# let's get the predictions
x_baglasso_train= bag_lasso_grid.predict(X_train)
x_baglasso_test = bag_lasso_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_baglasso_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_baglasso_train))))
print('train r2: {}'.format(r2_score(y_train, x_baglasso_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_baglasso_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_baglasso_test))))
print('test r2: {}'.format(r2_score(y_test, x_baglasso_test)))
print()
print(f'Best Mean Cross Validation Score is {bag_lasso_grid.best_score_}')
print(f'Best parameters {bag_lasso_grid.best_params_}')
print(f'Train score is {bag_lasso_grid.score(X_train,y_train)}')
print(f'Test score is {bag_lasso_grid.score(X_test,y_test)}')
```

```
train mse: 565445909.6571118
train rmse: 23779.106578194056
train r2: 0.9094392801032474

test mse: 853696103.4052668
test rmse: 29218.07836606074
test r2: 0.8757738967121659

Best Mean Cross Validation Score is 0.8849435910242107
Best parameters {'base_estimator__alpha': 1}
Train score is 0.9094392801032474
Test score is 0.8757738967121659
```

2.2 Pasting

2.2.1 With Decision Tree Regressor

[72]:
```
paste_dtree1 = BaggingRegressor(base_estimator=DecisionTreeRegressor(),␣
↪bootstrap=False, random_state=0, oob_score=False)

paste_dtree1_param = {
                'base_estimator__max_depth': range(1,10),
                'max_samples':  [0.8,1],
                'n_estimators': range(1,80,5)}
paste_dtree1_grid = GridSearchCV(paste_dtree1, paste_dtree1_param,cv=5,␣
↪return_train_score=True)
paste_dtree1_grid.fit(X_train,y_train)
```

[72]:
```
GridSearchCV(cv=5, error_score=nan,
estimator=BaggingRegressor(base_estimator=DecisionTreeRegressor(ccp_alpha=0.0,
criterion='mse',
max_depth=None,
max_features=None,
max_leaf_nodes=None,
min_impurity_decrease=0.0,
min_impurity_split=None,
min_samples_leaf=1,
min_samples_split=2,
min_weight_fraction_leaf=0.0,
presort='deprecated',
random_state=None,
splitter='be…
                                        bootstrap_features=False,
                                        max_features=1.0, max_samples=1.0,
                                        n_estimators=10, n_jobs=None,
                                        oob_score=False, random_state=0,
                                        verbose=0, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'base_estimator__max_depth': range(1, 10),
                         'max_samples': [0.8, 1],
                         'n_estimators': range(1, 80, 5)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

Results

[73]:
```
# let's get the predictions
x_pastetree_train= paste_dtree1_grid.predict(X_train)
x_pastetree_test = paste_dtree1_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_pastetree_train)))
```

```
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_pastetree_train))))
print('train r2: {}'.format(r2_score(y_train, x_pastetree_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_pastetree_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test,␣
 ↪x_pastetree_test))))
print('test r2: {}'.format(r2_score(y_test, x_pastetree_test)))
print()
print(f'Best Mean Cross Validation Score is {paste_dtree1_grid.best_score_}')
print(f'Best parameters {paste_dtree1_grid.best_params_}')
print(f'Train score is {paste_dtree1_grid.score(X_train,y_train)}')
print(f'Test score is {paste_dtree1_grid.score(X_test,y_test)}')
```

```
train mse: 151317451.74681643
train rmse: 12301.115874050469
train r2: 0.9757652904918109

test mse: 954334002.3152863
test rmse: 30892.296811912292
test r2: 0.8611295121650201

Best Mean Cross Validation Score is 0.8572589293630738
Best parameters {'base_estimator__max_depth': 9, 'max_samples': 0.8,
'n_estimators': 36}
Train score is 0.9757652904918109
Test score is 0.8611295121650201
```

2.2.2 With HW 2 Best Model - Lasso

[74]:
```
paste_lasso = BaggingRegressor(base_estimator=Lasso(), bootstrap=False,␣
 ↪random_state=0, oob_score=False)

paste_dtree2_param = {'base_estimator__alpha': [1, 1e4, 1e5]}

paste_lasso_grid = GridSearchCV(paste_lasso, paste_dtree2_param,cv=5,␣
 ↪return_train_score=True)
paste_lasso_grid.fit(X_train,y_train)
```

[74]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=BaggingRegressor(base_estimator=Lasso(alpha=1.0,
                                                             copy_X=True,
                                                             fit_intercept=True,
                                                             max_iter=1000,
                                                             normalize=False,
                                                             positive=False,
                                                             precompute=False,
```

```
                                                        random_state=None,
                                                        selection='cyclic',
                                                        tol=0.0001,
                                                        warm_start=False),
                                    bootstrap=False,
                                    bootstrap_features=False,
                                    max_features=1.0, max_samples=1.0,
                                    n_estimators=10, n_jobs=None,
                                    oob_score=False, random_state=0,
                                    verbose=0, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'base_estimator__alpha': [1, 10000.0, 100000.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

Results

[75]:
```
# let's get the predictions
x_pastelasso_train= paste_lasso_grid.predict(X_train)
x_pastelasso_test = paste_lasso_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_pastelasso_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_pastelasso_train))))
print('train r2: {}'.format(r2_score(y_train, x_pastelasso_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_pastelasso_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test,␣
 ↪x_pastelasso_test))))
print('test r2: {}'.format(r2_score(y_test, x_pastelasso_test)))
print()
print(f'Best Mean Cross Validation Score is {paste_lasso_grid.best_score_}')
print(f'Best parameters {paste_lasso_grid.best_params_}')
print(f'Train score is {paste_lasso_grid.score(X_train,y_train)}')
print(f'Test score is {paste_lasso_grid.score(X_test,y_test)}')
```

```
train mse: 552539222.3512007
train rmse: 23506.15286156373
train r2: 0.9115063901025299

test mse: 857849072.1153542
test rmse: 29289.0606219345
test r2: 0.87516957496597

Best Mean Cross Validation Score is 0.881849542095595
Best parameters {'base_estimator__alpha': 1}
```

```
Train score is 0.9115063901025299
Test score is 0.87516957496597
```

2.3 Random Forest

[76]:
```
from sklearn.ensemble import RandomForestRegressor
```

[77]:
```
rf =RandomForestRegressor(random_state=42)
rf_param = {
    'n_estimators': range(1,300,10),#[200, 500],
    'max_features': ['auto', 'sqrt', 'log2'],
    'max_depth' : range(1,20,2)#[2,4,5,6,7,8],
}

rf_grid = GridSearchCV(rf, rf_param,cv=5, return_train_score=True)
rf_grid.fit(X_train,y_train)
```

[77]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=RandomForestRegressor(bootstrap=True, ccp_alpha=0.0,
                                             criterion='mse', max_depth=None,
                                             max_features='auto',
                                             max_leaf_nodes=None,
                                             max_samples=None,
                                             min_impurity_decrease=0.0,
                                             min_impurity_split=None,
                                             min_samples_leaf=1,
                                             min_samples_split=2,
                                             min_weight_fraction_leaf=0.0,
                                             n_estimators=100, n_jobs=None,
                                             oob_score=False, random_state=42,
                                             verbose=0, warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'max_depth': range(1, 20, 2),
                         'max_features': ['auto', 'sqrt', 'log2'],
                         'n_estimators': range(1, 300, 10)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

2.3.1 Results

[78]:
```
# let's get the predictions
x_rfgrid_train= rf_grid.predict(X_train)
x_rfgrid_test = rf_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_rfgrid_train)))
```

```
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_rfgrid_train))))
print('train r2: {}'.format(r2_score(y_train, x_rfgrid_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_rfgrid_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_rfgrid_test))))
print('test r2: {}'.format(r2_score(y_test, x_rfgrid_test)))
print()
print(f'Best Mean Cross Validation Score is {rf_grid.best_score_}')
print(f'Best parameters {rf_grid.best_params_}')
print(f'Train score is {rf_grid.score(X_train,y_train)}')
print(f'Test score is {rf_grid.score(X_test,y_test)}')
```

```
train mse: 122538951.61327057
train rmse: 11069.731325252233
train r2: 0.9803743992414402

test mse: 932265620.8565763
test rmse: 30533.025085251156
test r2: 0.8643408060007887

Best Mean Cross Validation Score is 0.8767927179403199
Best parameters {'max_depth': 13, 'max_features': 'sqrt', 'n_estimators': 291}
Train score is 0.9803743992414402
Test score is 0.8643408060007887
```

2.4 Adaboost Regressor

[79]:
```
from sklearn.ensemble import AdaBoostRegressor
```

[80]:
```
ada␣
 ↪=AdaBoostRegressor(base_estimator=DecisionTreeRegressor(),random_state=42,learning_rate=1.
 ↪0)
ada_param = {
    'base_estimator__max_depth':range(1,20,2),
    'n_estimators': range(1,300,10),
    'loss':['linear', 'square', 'exponential']
}

ada_grid = GridSearchCV(ada, ada_param,cv=5, return_train_score=True)
ada_grid.fit(X_train,y_train)
```

[80]:
```
GridSearchCV(cv=5, error_score=nan,
estimator=AdaBoostRegressor(base_estimator=DecisionTreeRegressor(ccp_alpha=0.0,
criterion='mse',
max_depth=None,
max_features=None,
```

```
max_leaf_nodes=None,
min_impurity_decrease=0.0,
min_impurity_split=None,
min_samples_leaf=1,
min_samples_split=2,
min_weight_fraction_leaf=0.0,
presort='deprecated',
random_state=None,
splitter='best'),
                                        learning_rate=1.0, loss='linear',
                                        n_estimators=50, random_state=42),
             iid='deprecated', n_jobs=None,
             param_grid={'base_estimator__max_depth': range(1, 20, 2),
                         'loss': ['linear', 'square', 'exponential'],
                         'n_estimators': range(1, 300, 10)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

2.4.1 Results

[81]:
```
# let's get the predictions
x_adagrid_train= ada_grid.predict(X_train)
x_adagrid_test = ada_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_adagrid_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_adagrid_train))))
print('train r2: {}'.format(r2_score(y_train, x_adagrid_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_adagrid_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_adagrid_test))))
print('test r2: {}'.format(r2_score(y_test, x_adagrid_test)))
print()
print(f'Best Mean Cross Validation Score is {ada_grid.best_score_}')
print(f'Best parameters {ada_grid.best_params_}')
print(f'Train score is {ada_grid.score(X_train,y_train)}')
print(f'Test score is {ada_grid.score(X_test,y_test)}')
```

```
train mse: 59039229.255843244
train rmse: 7683.698930583059
train r2: 0.9905443915815029

test mse: 888472231.5703418
test rmse: 29807.251325312467
test r2: 0.8707134274513209
```

```
Best Mean Cross Validation Score is 0.8819499238825339
Best parameters {'base_estimator__max_depth': 17, 'loss': 'square',
'n_estimators': 291}
Train score is 0.9905443915815029
Test score is 0.8707134274513209
```

2.5 Gradient Boost Regressor

[82]:
```
from sklearn.ensemble import GradientBoostingRegressor
```

[83]:
```
gboostparam = {'max_depth':range(1,12),
               'n_estimators':range(45,60,5),
               'loss':['ls', 'lad', 'huber', 'quantile'],
               'max_features':['auto','sqrt','log2']}


gboost = GridSearchCV(estimator = GradientBoostingRegressor(learning_rate=0.1,
                                                            min_samples_split=2,
                                                            min_samples_leaf=1,
                                                            subsample=1,
#                                                             max_features='sqrt',
                                                            random_state=10),
                                                            param_grid = gboostparam,
                                                            n_jobs=-1,cv=5)

gboost.fit(X_train,y_train)
```

[83]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=GradientBoostingRegressor(alpha=0.9, ccp_alpha=0.0,
                                                 criterion='friedman_mse',
                                                 init=None, learning_rate=0.1,
                                                 loss='ls', max_depth=3,
                                                 max_features=None,
                                                 max_leaf_nodes=None,
                                                 min_impurity_decrease=0.0,
                                                 min_impurity_split=None,
                                                 min_samples_leaf=1,
                                                 min_samples_split=2,
                                                 min_weight_fraction_leaf=0.0,
                                                 n_estimators=100,
                                                 n_iter_n…
                                                 presort='deprecated',
                                                 random_state=10, subsample=1,
                                                 tol=0.0001,
                                                 validation_fraction=0.1,
                                                 verbose=0, warm_start=False),
```

```
                iid='deprecated', n_jobs=-1,
                param_grid={'loss': ['ls', 'lad', 'huber', 'quantile'],
                            'max_depth': range(1, 12),
                            'max_features': ['auto', 'sqrt', 'log2'],
                            'n_estimators': range(45, 60, 5)},
                pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                scoring=None, verbose=0)
```

2.5.1 Results

[84]:
```
# let's get the predictions
x_gboost_train= gboost.predict(X_train)
x_gboost_test = gboost.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_gboost_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_gboost_train))))
print('train r2: {}'.format(r2_score(y_train, x_gboost_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_gboost_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_gboost_test))))
print('test r2: {}'.format(r2_score(y_test, x_gboost_test)))
print()
print(f'Best Mean Cross Validation Score is {gboost.best_score_}')
print(f'Best parameters {gboost.best_params_}')
print(f'Train score is {gboost.score(X_train,y_train)}')
print(f'Test score is {gboost.score(X_test,y_test)}')
```

```
train mse: 210402353.29194453
train rmse: 14505.252610414771
train r2: 0.9663023672880685

test mse: 1106890497.8616946
test rmse: 33269.96389931457
test r2: 0.8389301617200744

Best Mean Cross Validation Score is 0.8918768459494615
Best parameters {'loss': 'ls', 'max_depth': 5, 'max_features': 'log2',
'n_estimators': 55}
Train score is 0.9663023672880685
Test score is 0.8389301617200744
```

2.6 Extra Trees

[85]:
```
from sklearn.ensemble import ExtraTreesRegressor
```

[86]:
```
extree= ExtraTreesRegressor(random_state=42)
etr_param = {
    'n_estimators': range(2,250,5),
    'max_features': ['auto', 'sqrt', 'log2'],
    'max_depth' : range(2,20,5),
}
etr_grid = GridSearchCV(extree,␣
 ↪etr_param,cv=5,n_jobs=-1,return_train_score=True, )
etr_grid.fit(X_train,y_train)
```

[86]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=ExtraTreesRegressor(bootstrap=False, ccp_alpha=0.0,
                                           criterion='mse', max_depth=None,
                                           max_features='auto',
                                           max_leaf_nodes=None,
                                           max_samples=None,
                                           min_impurity_decrease=0.0,
                                           min_impurity_split=None,
                                           min_samples_leaf=1,
                                           min_samples_split=2,
                                           min_weight_fraction_leaf=0.0,
                                           n_estimators=100, n_jobs=None,
                                           oob_score=False, random_state=42,
                                           verbose=0, warm_start=False),
             iid='deprecated', n_jobs=-1,
             param_grid={'max_depth': range(2, 20, 5),
                         'max_features': ['auto', 'sqrt', 'log2'],
                         'n_estimators': range(2, 250, 5)},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

2.6.1 Results

[87]:
```
# let's get the predictions
x_etr_train= etr_grid.predict(X_train)
x_etr_test = etr_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_etr_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_etr_train))))
print('train r2: {}'.format(r2_score(y_train, x_etr_train)))
print()
```

```
print('test mse: {}'.format(mean_squared_error(y_test, x_etr_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_etr_test))))
print('test r2: {}'.format(r2_score(y_test, x_etr_test)))
print()
print(f'Best Mean Cross Validation Score is {etr_grid.best_score_}')
print(f'Best parameters {etr_grid.best_params_}')
print(f'Train score is {etr_grid.score(X_train,y_train)}')
print(f'Test score is {etr_grid.score(X_test,y_test)}')
```

```
train mse: 5741824.059904766
train rmse: 2396.210353851424
train r2: 0.9990804005979974

test mse: 929787656.6985651
test rmse: 30492.419659623032
test r2: 0.8647013884495182

Best Mean Cross Validation Score is 0.8804371492768851
Best parameters {'max_depth': 17, 'max_features': 'sqrt', 'n_estimators': 162}
Train score is 0.9990804005979974
Test score is 0.8647013884495182
```

2.7 XGBoost Regressor

[88]:
```
# pip install xgboost
```

[89]:
```
from xgboost import XGBRegressor
```

[90]:
```
xgbr= XGBRegressor(random_state=42)
xgbr_param = {
              'max_depth' : range(2,20,2),
              'n_estimators' : range(2,200,10),
              'learning_rate' : [0.1],
               'min_child_weight' : range(1,8,1),
                'subsample':[0.6,0.7,0.8,0.9,1]
             }
xgbr_grid = GridSearchCV(xgbr, xgbr_param,cv=5,n_jobs=-1,␣
 ↪return_train_score=True)
xgbr_grid.fit(X_train,y_train)
```

[90]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=XGBRegressor(base_score=None, booster=None,
                                    colsample_bylevel=None,
                                    colsample_bynode=None,
                                    colsample_bytree=None, gamma=None,
                                    gpu_id=None, importance_type='gain',
                                    interaction_constraints=None,
```

```
                                    learning_rate=None, max_delta_step=None,
                                    max_depth=None, min_child_weight=None,
                                    missing=nan, monotone_constraints=None,
                                    n_estima…
                                    reg_lambda=None, scale_pos_weight=None,
                                    subsample=None, tree_method=None,
                                    validate_parameters=False, verbosity=None),
             iid='deprecated', n_jobs=-1,
             param_grid={'learning_rate': [0.1], 'max_depth': range(2, 20, 2),
                         'min_child_weight': range(1, 8),
                         'n_estimators': range(2, 200, 10),
                         'subsample': [0.6, 0.7, 0.8, 0.9, 1]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

[91]:
```
# let's get the predictions
x_xgbr_train= xgbr_grid.predict(X_train)
x_xgbr_test = xgbr_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_xgbr_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_xgbr_train))))
print('train r2: {}'.format(r2_score(y_train, x_xgbr_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_xgbr_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_xgbr_test))))
print('test r2: {}'.format(r2_score(y_test, x_xgbr_test)))
print()
print(f'Best Mean Cross Validation Score is {xgbr_grid.best_score_}')
print(f'Best parameters {xgbr_grid.best_params_}')
print(f'Train score is {xgbr_grid.score(X_train,y_train)}')
print(f'Test score is {xgbr_grid.score(X_test,y_test)}')
```

```
train mse: 98739443.27826326
train rmse: 9936.772276663245
train r2: 0.9841860823241139

test mse: 847173787.4212183
test rmse: 29106.249971805337
test r2: 0.8767229954557099

Best Mean Cross Validation Score is 0.8984774624760332
Best parameters {'learning_rate': 0.1, 'max_depth': 4, 'min_child_weight': 1,
'n_estimators': 192, 'subsample': 0.8}
Train score is 0.9841860823241139
Test score is 0.8767229954557099
```

2.8 Summary

[92]:
```
regressors={#'LinearReg':lr,
'Ridge':grid_ridge,
'Lasso':grid_lasso,
'LinearSGD':grid_linearsgd,
'Polynomial':grid_poly,
'elasticnet':grid_elasticnet,
'GridLRRidge':grid_search_linear,
'GridLRLasso':grid_search_linear2,
'GridRF':grid_rf,
# 'KNN':knnreg,
'GridElastic':grid_elasticnet,
'GridDecisionTree':grid_dtree,
'SVC':grid_svc_kernel,
'BaggingDTree':bag_dtree1_grid,
'BaggingLasso':bag_lasso_grid,
'PastingDTree':paste_dtree1_grid,
'PastingLasso':paste_lasso_grid,
'RandomForest':rf_grid,
'AdaBoost':rf_grid,
'GradientBoostR':gboost,
'ExtraTrees':etr_grid,
'XGBoost':xgbr_grid,
}
```

[93]:
```
regressors.keys()
```

[93]:
```
dict_keys(['Ridge', 'Lasso', 'LinearSGD', 'Polynomial', 'elasticnet',
'GridLRRidge', 'GridLRLasso', 'GridRF', 'GridElastic', 'GridDecisionTree',
'SVC', 'BaggingDTree', 'BaggingLasso', 'PastingDTree', 'PastingLasso',
'RandomForest', 'AdaBoost', 'GradientBoostR', 'ExtraTrees', 'XGBoost'])
```

[94]:
```
results_mean_std = []
for  key, value in regressors.items():
    mean = value.cv_results_['mean_test_score'][value.best_index_]
    std=value.cv_results_['std_test_score'][value.best_index_]

    results_mean_std.append({
        "model": key,
        "mean": mean,
        "std": std
    })
```

[95]:
```
# Create a Pandas DataFrame with the mean+std results
accuracy_df = pd.DataFrame(results_mean_std, columns=['model', 'mean', 'std'])
```

[96]:
```
# Show the accuracy dataframe

accuracy_df.sort_values(by=['mean'], inplace=True,ascending=False)
accuracy_df
```

[96]:

	model	mean	std
19	XGBoost	8.984775e-01	8.966995e-03
17	GradientBoostR	8.918768e-01	1.466126e-02
12	BaggingLasso	8.849436e-01	1.222205e-02
0	Ridge	8.843424e-01	3.178374e-02
1	Lasso	8.843050e-01	3.179290e-02
4	elasticnet	8.840700e-01	1.039538e-02
8	GridElastic	8.840700e-01	1.039538e-02
5	GridLRRidge	8.818970e-01	1.141903e-02
6	GridLRLasso	8.818495e-01	1.142073e-02
14	PastingLasso	8.818495e-01	1.142073e-02
18	ExtraTrees	8.804371e-01	1.394497e-02
15	RandomForest	8.767927e-01	1.611594e-02
16	AdaBoost	8.767927e-01	1.611594e-02
2	LinearSGD	8.765910e-01	1.366770e-02
11	BaggingDTree	8.701118e-01	1.681030e-02
13	PastingDTree	8.572589e-01	1.829952e-02
9	GridDecisionTree	7.573303e-01	2.847110e-02
10	SVC	7.104416e-01	2.673301e-02
7	GridRF	-1.253123e+21	2.506247e+21
3	Polynomial	-9.790049e+22	1.950468e+23

[97]:
```
# Create a prediction of all models on the test set
predictions_all = {}
for  key, value in regressors.items():
    # Get best estimator
    best_model = value.best_estimator_

    # Predict test labels
    predictions = best_model.predict(X_test)

    # Save predictions to a list
    predictions_all[key] = predictions
```

[98]:
```
# Creat a DataFrame for the predictions
pred = pd.DataFrame(predictions_all)
```

[99]:
```
pred.head()
```

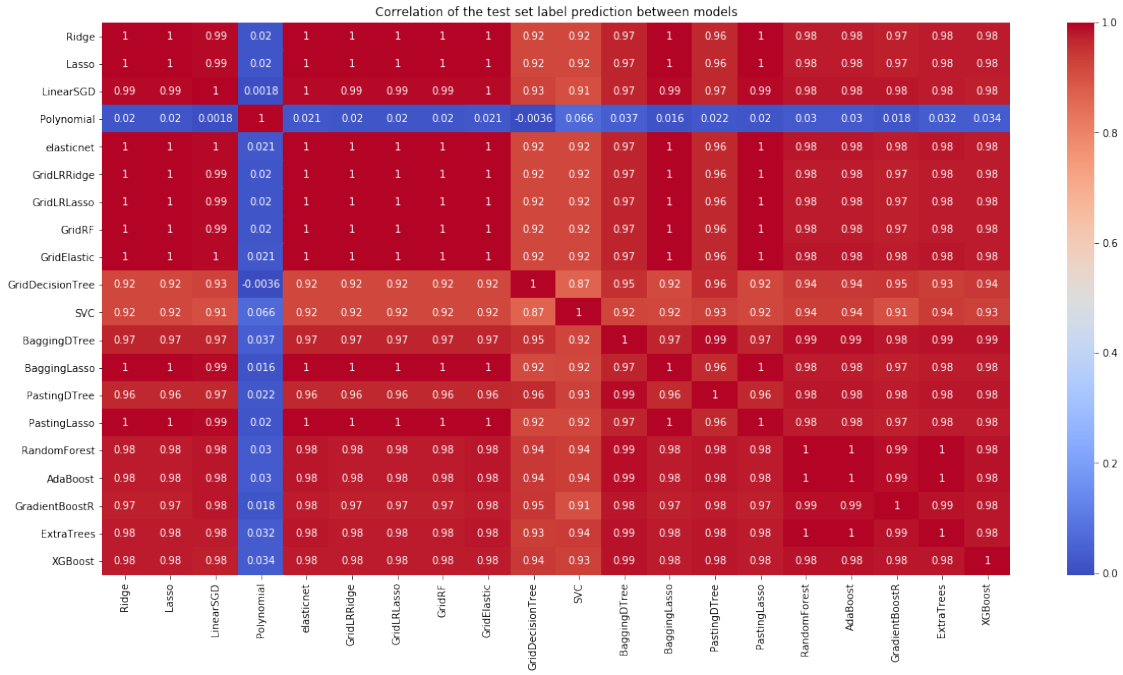
[99]:

	Ridge	Lasso	LinearSGD	Polynomial	elasticnet	\
0	259427.918908	259358.714345	269968.912408	-2.401626e+15	263655.245673	
1	130977.047829	130977.454966	136605.961715	-8.888887e+14	130804.224834	

```
2  118352.334635  118328.412013  120844.488906  2.467426e+14  120690.792966
3  219592.797874  219614.219922  219618.652969  1.198736e+15  217482.466827
4   91161.872462   91146.795565   93556.522122  2.906841e+14   92806.958086

     GridLRRidge    GridLRLasso         GridRF    GridElastic  \
0  259427.918908  259358.714345  258576.640044  263655.245673
1  130977.047829  130977.454966  130385.243135  130804.224834
2  118352.334635  118328.412013  117989.111328  120690.792966
3  219592.797874  219614.219922  220890.140789  217482.466827
4   91161.872462   91146.795565   91502.241892   92806.958086

   GridDecisionTree     SVC   BaggingDTree   BaggingLasso   PastingDTree  \
0     286141.333333  237000  231628.891408  253304.203849  260380.403015
1     148118.800000  105000  138410.074763  135019.758648  142482.141309
2     118911.000000  135000  121417.290889  118712.599413  118725.602426
3     229747.629630  178000  234395.674515  218284.457610  239981.004528
4     118911.000000  113000   97929.805069   88489.935148   98999.445234

    PastingLasso   RandomForest       AdaBoost  GradientBoostR     ExtraTrees  \
0  259358.714345  252395.782594  252395.782594   279172.467178  256034.145142
1  130977.454966  140416.801495  140416.801495   144826.895238  136406.530809
2  118328.412013  125970.464256  125970.464256   126477.951094  132510.120732
3  219614.219922  209285.267185  209285.267185   210454.548365  201347.542099
4   91146.795565  100051.392538  100051.392538   100665.764154   96968.065484

         XGBoost
0  273605.375000
1  134782.234375
2  118255.343750
3  221607.421875
4   93816.242188
```

[100]:
```
# Plot a heatmap of all correlations for easier visualization
fig, ax = plt.subplots(nrows=1, ncols=1, figsize=(20,10))
g = sns.heatmap(pred.corr(), annot=True, cmap='coolwarm', ax=ax)
g.set_title('Correlation of the test set label prediction between models')
```

[100]:
```
Text(0.5, 1, 'Correlation of the test set label prediction between models')
```



[101]:
```
def get_redundant_pairs(df):
    '''Get diagonal and lower triangular pairs of correlation matrix'''
    pairs_to_drop = set()
    cols = df.columns
    for i in range(0, df.shape[1]):
        for j in range(0, i+1):
            pairs_to_drop.add((cols[i], cols[j]))
    return pairs_to_drop

def get_top_abs_correlations(df, n=5):
    au_corr = df.corr().abs().unstack()
    labels_to_drop = get_redundant_pairs(df)
    au_corr = au_corr.drop(labels=labels_to_drop).sort_values(ascending=True)
    return au_corr[0:n]
```

[102]:
```
print("Top Least Correlations")
print(get_top_abs_correlations(pred, 5))
```

```
Top Least Correlations
LinearSGD   Polynomial          0.001773
Polynomial  GridDecisionTree    0.003570
            BaggingLasso        0.015869
            GradientBoostR      0.018109
            GridRF              0.019594
dtype: float64
```

2.9 Stacking

2.10 Voting top 5

[103]:
```
from sklearn.ensemble import VotingRegressor
```

[104]:
```
vclf1 = VotingRegressor( estimators=
                              [('XGBoost', xgbr_grid.best_estimator_),
                               ('GradientBoost', gboost.best_estimator_),
                               ('BaggingLasso', bag_lasso_grid.best_estimator_),
                               ('PastingDTree', bag_lasso_grid.best_estimator_),
                               ('Ridge', grid_ridge.best_estimator_)
                              ] )
vclf1_param = { }
vclf1_grid = GridSearchCV(vclf1, vclf1_param,cv=5, return_train_score=True)
vclf1_grid.fit(X_train,y_train)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
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packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
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C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
```

```
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
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packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
```

[104]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=VotingRegressor(estimators=[('XGBoost',
                                                    XGBRegressor(base_score=0.5,
                                                                 booster=None,
colsample_bylevel=1,
colsample_bynode=1,
colsample_bytree=1,
                                                                 gamma=0,
                                                                 gpu_id=-1,
importance_type='gain',
interaction_constraints=None,
learning_rate=0.1,
max_delta_step=0,
                                                                 max_depth=4,
min_child_weight=1,
                                                                 missing=nan,
monotone_constraints…
```

```
        n_jobs=None,
        oob_score=True,
        random_state=0,
                                                                    verbose=0,
        warm_start=False)),
                                                  ('Ridge',
                                                   Ridge(alpha=1, copy_X=True,
                                                         fit_intercept=True,
                                                         max_iter=None,
                                                         normalize=False,
                                                         random_state=None,
                                                         solver='auto',
                                                         tol=0.001))],
                                       n_jobs=None, weights=None),
                 iid='deprecated', n_jobs=None, param_grid={},
                 pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
                 scoring=None, verbose=0)
```

[105]:
```
# let's get the predictions
x_vclf1_train= vclf1_grid.predict(X_train)
x_vclf1_test = vclf1_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_vclf1_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_vclf1_train))))
print('train r2: {}'.format(r2_score(y_train, x_vclf1_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_vclf1_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_vclf1_test))))
print('test r2: {}'.format(r2_score(y_test, x_vclf1_test)))
print()
print(f'Best Mean Cross Validation Score is {vclf1_grid.best_score_}')
print(f'Best parameters {vclf1_grid.best_params_}')
print(f'Train score is {vclf1_grid.score(X_train,y_train)}')
print(f'Test score is {vclf1_grid.score(X_test,y_test)}')
```

```
train mse: 317633603.336003
train rmse: 17822.2782869083
train r2: 0.9491284183151113

test mse: 822879018.3587837
test rmse: 28685.867920611774
test r2: 0.8802582634262037

Best Mean Cross Validation Score is 0.8999858356957512
Best parameters {}
```

```
Train score is 0.9491284183151113
Test score is 0.8802582634262037
```

2.11 Voting Least Correlated

[106]:
```python
vclf3 = VotingRegressor(estimators=
                              [('LinearSGD', grid_linearsgd.best_estimator_),
                                ('Polynomial', grid_poly.best_estimator_),
                                ('GridDecisionTree', grid_dtree.best_estimator_),
                                ('BaggingLasso', bag_lasso_grid.best_estimator_),
                                ('GradientBoostR', gboost.best_estimator_)
                               ] )
vclf3_param = { }
vclf3_grid = GridSearchCV(vclf3, vclf3_param,cv=5, return_train_score=True)
vclf3_grid.fit(X_train,y_train)
```

```
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
C:\Users\nabhs\Anaconda3\envs\buan6341_2020\lib\site-
packages\sklearn\ensemble\_bagging.py:1056: UserWarning: Some inputs do not have
OOB scores. This probably means too few estimators were used to compute any
reliable oob estimates.
  warn("Some inputs do not have OOB scores. "
```

[106]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=VotingRegressor(estimators=[('LinearSGD',
                                                    Pipeline(memory=None,
                                                             steps=[('scaler',
MinMaxScaler(copy=True,
  feature_range=(0,
                 1))),
                                                                    ('sgd_reg',
SGDRegressor(alpha=0.01,
  average=False,
  early_stopping=False,
  epsilon=0.1,
  eta0=0.05,
  fit_intercept=True,
  l1_ratio=0.15,
  learning_rate='invscaling',
  loss='squared_loss',
  max_iter=1…
min_samples_split=2,
min_weight_fraction_leaf=0.0,
n_estimators=55,
n_iter_no_change=None,
presort='deprecated',
random_state=10,
subsample=1,
tol=0.0001,
validation_fraction=0.1,
verbose=0,
warm_start=False))],
                                         n_jobs=None, weights=None),
             iid='deprecated', n_jobs=None, param_grid={},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

[107]:
```
# let's get the predictions
x_vclf3_train= vclf3_grid.predict(X_train)
x_vclf3_test = vclf3_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_vclf3_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train, x_vclf3_train))))
print('train r2: {}'.format(r2_score(y_train, x_vclf3_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_vclf3_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_vclf3_test))))
print('test r2: {}'.format(r2_score(y_test, x_vclf3_test)))
```

```
print()
print(f'Best Mean Cross Validation Score is {vclf3_grid.best_score_}')
print(f'Best parameters {vclf3_grid.best_params_}')
print(f'Train score is {vclf3_grid.score(X_train,y_train)}')
print(f'Test score is {vclf3_grid.score(X_test,y_test)}')
```

```
train mse: 282747004.4125732
train rmse: 16815.08264661739
train r2: 0.954715788316905

test mse: 8.592991133805444e+28
test rmse: 293138041437911.0
test r2: -1.2504142866314648e+19

Best Mean Cross Validation Score is -2.7187395878116203e+20
Best parameters {}
Train score is 0.954715788316905
Test score is -1.2504142866314648e+19
```

2.12 Stacking Top 5

https://towardsdatascience.com/stacking-made-easy-with-sklearn-e27a0793c92b

[108]:
```
from sklearn.ensemble import StackingRegressor
```

[109]:
```
sregf1 = StackingRegressor(estimators=
                           [ ('GradientBoost', gboost.best_estimator_),
                             ('BaggingLasso', bag_lasso_grid.best_estimator_),
                             ('PastingDTree', bag_lasso_grid.best_estimator_),
                             ('Ridge', grid_ridge.best_estimator_)
                            ] , final_estimator=XGBRegressor())
sregf1_param = {
               'final_estimator__learning_rate' : [0.1],
               'final_estimator__max_depth':[4],
               'final_estimator__min_child_weight':[1],
               'final_estimator__n_estimators':[192],
               'final_estimator__subsample':[0.8],
               'n_jobs':[-1]
              }
sregf1_grid = GridSearchCV(sregf1, sregf1_param,cv=5, return_train_score=True )
sregf1_grid.fit(X_train,y_train)
```

[109]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=StackingRegressor(cv=None,
                                         estimators=[('GradientBoost',
GradientBoostingRegressor(alpha=0.9,
ccp_alpha=0.0,
criterion='friedman_mse',
```

```
        init=None,
        learning_rate=0.1,
        loss='ls',
        max_depth=5,
        max_features='log2',
        max_leaf_nodes=None,
        min_impurity_decrease=0.0,
        min_impurity_split=None,
        min_samples_leaf=1,
        min_samples_split…
                                                n_jobs=None, passthrough=False,
                                                verbose=0),
                     iid='deprecated', n_jobs=None,
                     param_grid={'final_estimator__learning_rate': [0.1],
                                 'final_estimator__max_depth': [4],
                                 'final_estimator__min_child_weight': [1],
                                 'final_estimator__n_estimators': [192],
                                 'final_estimator__subsample': [0.8], 'n_jobs': [-1]},
                     pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
                     scoring=None, verbose=0)
```

[110]:
```
# let's get the predictions
x_sregf1_train= sregf1_grid.predict(X_train)
x_sregf1_test = sregf1_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_sregf1_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_sregf1_train))))
print('train r2: {}'.format(r2_score(y_train, x_sregf1_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_sregf1_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_sregf1_test))))
print('test r2: {}'.format(r2_score(y_test, x_sregf1_test)))
print()
print(f'Best Mean Cross Validation Score is {sregf1_grid.best_score_}')
print(f'Best parameters {sregf1_grid.best_params_}')
print(f'Train score is {sregf1_grid.score(X_train,y_train)}')
print(f'Test score is {sregf1_grid.score(X_test,y_test)}')
```

```
train mse: 408279864.3139851
train rmse: 20205.93636320735
train r2: 0.9346106890152514

test mse: 825035315.361602
test rmse: 28723.427987648025
```

```
test r2: 0.8799444885675358

Best Mean Cross Validation Score is 0.87774060712915
Best parameters {'final_estimator__learning_rate': 0.1,
'final_estimator__max_depth': 4, 'final_estimator__min_child_weight': 1,
'final_estimator__n_estimators': 192, 'final_estimator__subsample': 0.8,
'n_jobs': -1}
Train score is 0.9346106890152514
Test score is 0.8799444885675358
```

2.13 Stacking Least Correlated

[111]:
```
sregf2 = StackingRegressor(estimators=
                           [('LinearSGD', grid_linearsgd.best_estimator_),
                            ('Polynomial', grid_poly.best_estimator_),
                            ('GridDecisionTree', grid_dtree.best_estimator_),
                            ('BaggingLasso', bag_lasso_grid.best_estimator_),
                            ('GradientBoostR', gboost.best_estimator_)
                           ],
                          final_estimator=XGBRegressor())
sregf2_param = {
                   'final_estimator__learning_rate' : [0.1],
               'final_estimator__max_depth':[4],
               'final_estimator__min_child_weight':[1],
               'final_estimator__n_estimators':[192],
               'final_estimator__subsample':[0.8],
               'n_jobs':[-1]
              }
sregf2_grid = GridSearchCV(sregf2, sregf2_param,cv=5, return_train_score=True)
sregf2_grid.fit(X_train,y_train)
```

[111]:
```
GridSearchCV(cv=5, error_score=nan,
             estimator=StackingRegressor(cv=None,
                                         estimators=[('LinearSGD',
                                                      Pipeline(memory=None,
                                                               steps=[('scaler',
MinMaxScaler(copy=True,
    feature_range=(0,
                   1))),
('sgd_reg',
SGDRegressor(alpha=0.01,
    average=False,
    early_stopping=False,
    epsilon=0.1,
    eta0=0.05,
    fit_intercept=True,
    l1_ratio=0.15,
```

```
    learning_rate='invscaling',
    loss='squared_loss',…
                                        n_jobs=None, passthrough=False,
                                        verbose=0),
             iid='deprecated', n_jobs=None,
             param_grid={'final_estimator__learning_rate': [0.1],
                         'final_estimator__max_depth': [4],
                         'final_estimator__min_child_weight': [1],
                         'final_estimator__n_estimators': [192],
                         'final_estimator__subsample': [0.8], 'n_jobs': [-1]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=0)
```

[112]:
```
# let's get the predictions
x_sregf2_train= sregf2_grid.predict(X_train)
x_sregf2_test = sregf2_grid.predict(X_test)

# check model performance:

print('train mse: {}'.format(mean_squared_error(y_train, x_sregf2_train)))
print('train rmse: {}'.format(sqrt(mean_squared_error(y_train,␣
 ↪x_sregf2_train))))
print('train r2: {}'.format(r2_score(y_train, x_sregf2_train)))
print()
print('test mse: {}'.format(mean_squared_error(y_test, x_sregf2_test)))
print('test rmse: {}'.format(sqrt(mean_squared_error(y_test, x_sregf2_test))))
print('test r2: {}'.format(r2_score(y_test, x_sregf2_test)))
print()
print(f'Best Mean Cross Validation Score is {sregf2_grid.best_score_}')
print(f'Best parameters {sregf2_grid.best_params_}')
print(f'Train score is {sregf2_grid.score(X_train,y_train)}')
print(f'Test score is {sregf2_grid.score(X_test,y_test)}')
```

```
train mse: 355270884.9509614
train rmse: 18848.630850832677
train r2: 0.9431005043099072

test mse: 685715224.4673892
test rmse: 26186.1647529261
test r2: 0.9002177356076231

Best Mean Cross Validation Score is 0.8665230017810973
Best parameters {'final_estimator__learning_rate': 0.1,
'final_estimator__max_depth': 4, 'final_estimator__min_child_weight': 1,
'final_estimator__n_estimators': 192, 'final_estimator__subsample': 0.8,
'n_jobs': -1}
Train score is 0.9431005043099072
```

```
Test score is 0.9002177356076231
```