Using Machine Learning to Develop a Supernatural Martian Substance

A visionary Company X is on a mission to build a self-sustaining city on the red planet. As part of this mission, scientists at Company X are developing a supernatural substance that can withstand Mars' extraterrestrial conditions. This substance will be the building block of this futuristic Martian city. Can Company X turn this idea into a reality? In this assignment, you will use machine learning to predict the quality of this substance based on historical data.

In [66]:

```
# Importing the libraries
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
import statistics as stat
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.svm import SVR
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
```

In [67]:

```
# Read CSV and print dataset shape
dataset = pd.read_csv('Data_Regression_Train.csv')
print('Data_Regression_Train.csv')
print(dataset.shape)
#dataset.head()
```

```
Data_Regression_Train.csv
(4000, 16)
```

We have 15 variables plus the outcome in this dataset. All data are numerical.
Our goal is to predict a numeric value for our target variable.

In [68]:

```
# Refactoring not useful
# dataset.rename(index = str, columns =
{'1':'cA','2':'cB','3':'cC','4':'cD','5':'cE','6':'cF','7':'cG','8':'RefractTest','9':'pA','10':'Ra
ctTest','11':'pB','12':'pC','13':'pD','14':'pE','15':'pF'}, inplace = True)
#print(list(dataset.columns.values))
dataset.head()
```

Out[68]:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0	0.392523	1.529391	-1.190833	-0.263736	1.034926	1.450200	0.483843	0	-1.606245	1	-0.904203	0.944466	-2.066797	-1.137719	0.80
1	-0.070729	-0.543017	0.367843	-1.098385	1.386151	1.367771	0.532697	0	0.225341	1	1.532991	-0.755426	-1.824408	-0.015377	0.27
2	0.791887	-0.687884	-0.284550	-1.183196	0.153298	2.464571	-1.443464	0	-1.319039	1	-0.548015	-1.118633	0.268017	-0.491163	0.56
3	-1.841402	0.564376	-0.545430	-1.121581	0.958518	-0.440323	0.565404	0	0.777585	0	1.264068	0.148411	2.719895	-0.521703	0.35
4	1.056602	-0.397247	0.638533	-0.180659	-0.443545	0.442201	-0.106325	0	-0.308637	1	-0.854053	0.221956	-1.009645	-0.044942	1.19

Let's create a list for the indipendent variables, which we will use later.

In [72]:

```
# Features list
features = (list(dataset.columns.values))[0:15]
```

Data Exploration

Using Pandas .describe() funcion we can have the dataset summary at a glance :

- There are **no missing data** in this 4000 rows dataset.
- **No zero-variance variables**. Which means potentially, they all carry some information.
- By looking at 1st and 3rd quartile of the distribution, we can suppose that all the variables have a symmetric, gaussian, distribution. The only exceptions are dummies variable "8" and variable '10'.
- Almost all the data are 0-centered (mean) and with standard error close to 1. Thus they are in scale.

In [73]:

```
# Dataset description
dataset.describe()
# no missing values, no zero variance features
```

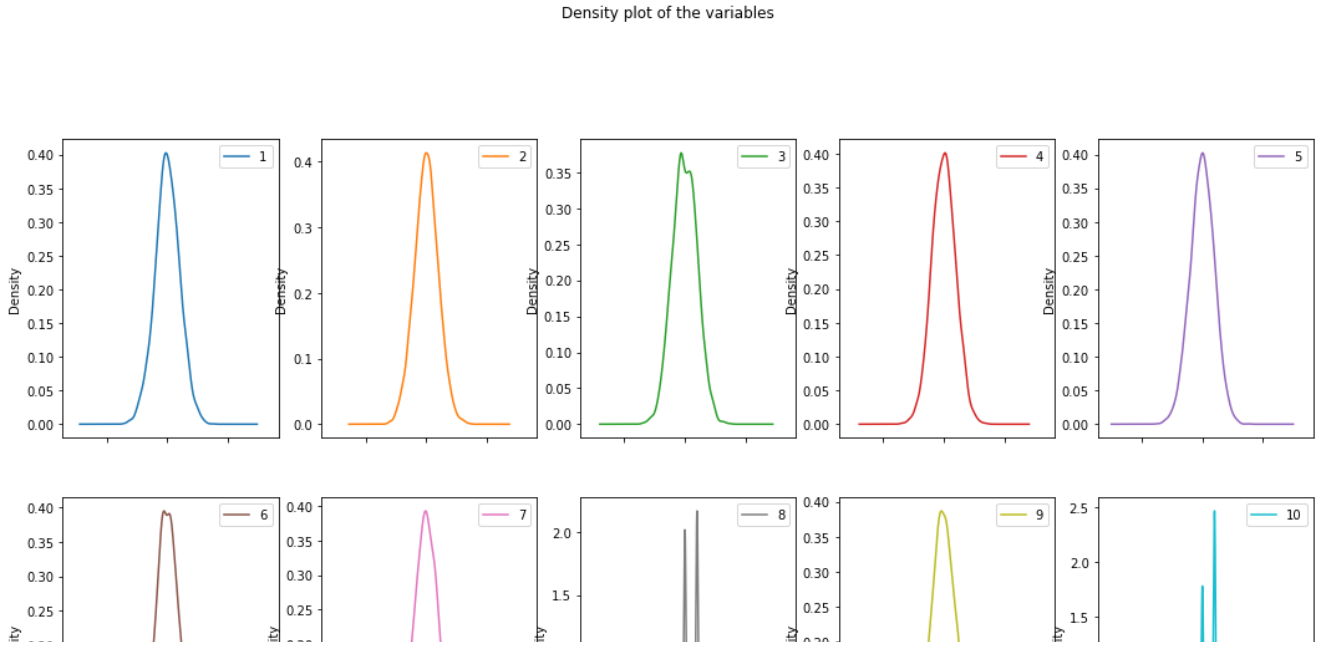
Out[73]:

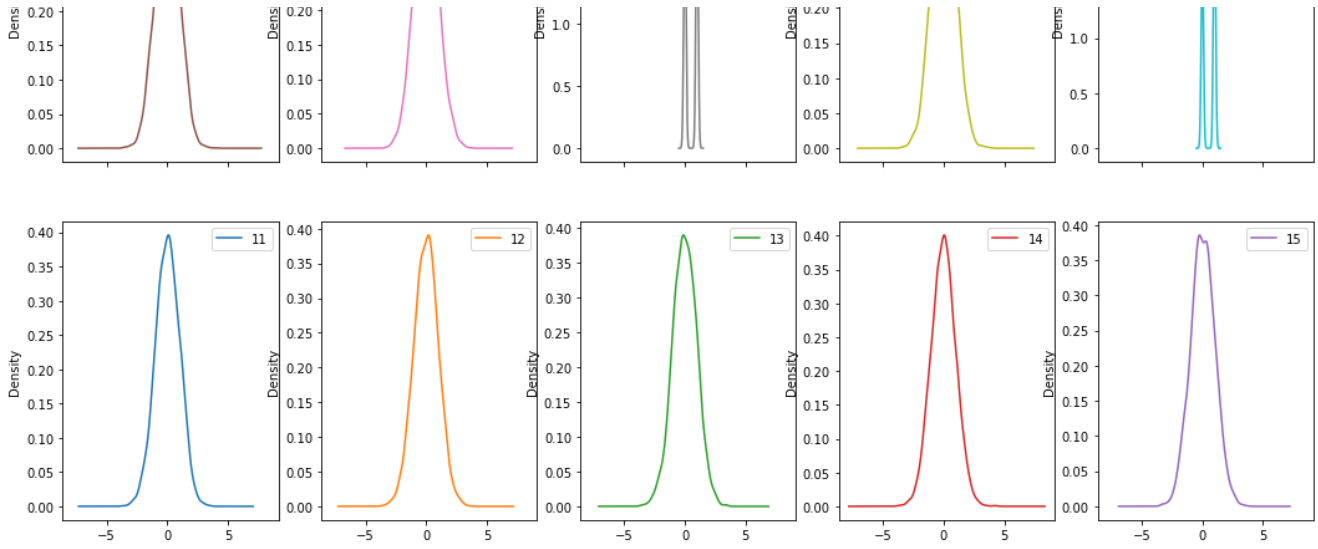
	1	2	3	4	5	6	7	8	9	
count	4000.000000	4000.000000	4000.000000	4000.000000	4000.000000	4000.000000	4000.000000	4000.000000	4000.000000	4000.00
mean	0.000261	0.017734	-0.007795	0.012498	-0.010918	-0.016477	0.010572	0.518000	-0.007874	0.58
std	1.017056	0.980291	1.011659	0.976791	0.995160	0.978880	1.007879	0.499738	1.001198	0.49
min	-3.569790	-3.054249	-3.440784	-3.448280	-3.747447	-3.581474	-3.243878	0.000000	-3.458497	0.00
25%	-0.665659	-0.625217	-0.699968	-0.650466	-0.666369	-0.664545	-0.674427	0.000000	-0.685799	0.00
50%	-0.009536	0.016039	-0.014302	0.015137	0.001239	-0.020759	0.001848	1.000000	-0.023406	1.00
75%	0.672891	0.660136	0.698973	0.666435	0.666005	0.642303	0.696575	1.000000	0.679844	1.00
max	3.734620	3.547635	3.676205	3.542074	3.741580	3.958712	3.643804	1.000000	3.800605	1.00

The distribution plot of the variables confirm that **they all have a Gaussian Distribution**.

In [74]:

```
# Kernel density esimation
dataset.drop('Target', axis=1).plot.kde(figsize=(18,15), layout=(3,5),subplots = True,title = "Dens
ity plot of the variables")
plt.show()
```





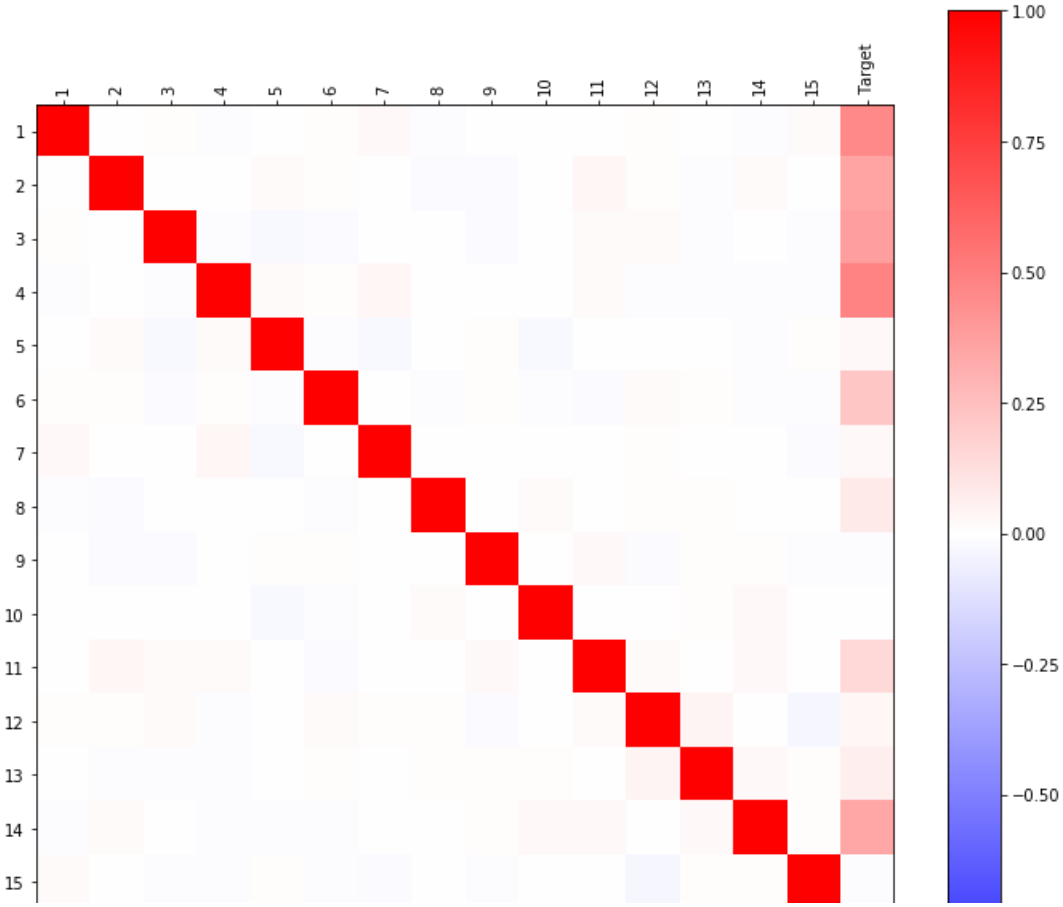
By looking at the correlation heatmap, we can see that some variables are more correlated to the target, while some are not correlated. This is confirmed by the univariate scatter plot right after.
The important information from this heatmap is that variables are indipendent, thus there is **absence of multicollinearity**.

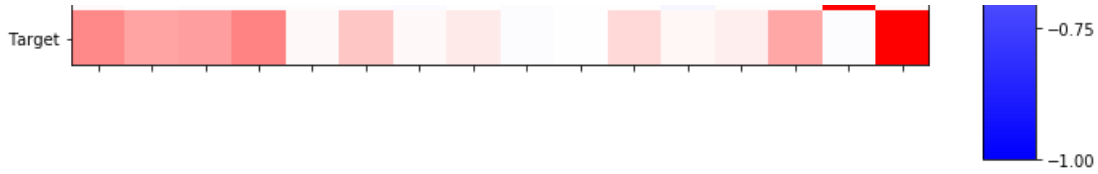
In [75]:

```
# Plot correlation heatmap
correlations = dataset.corr()

fig = plt.figure(figsize = (12,12))
ax = fig.add_subplot(111)
cax = ax.matshow(correlations, vmin=-1, vmax=1, cmap = 'bwr')
fig.colorbar(cax)
ticks = np.arange(0,16,1)
ax.set_xticks(ticks)
ax.set_yticks(ticks)
ax.set_xticklabels(list(dataset.columns.values),rotation='vertical')
ax.set_yticklabels(list(dataset.columns.values) )

plt.show()
```

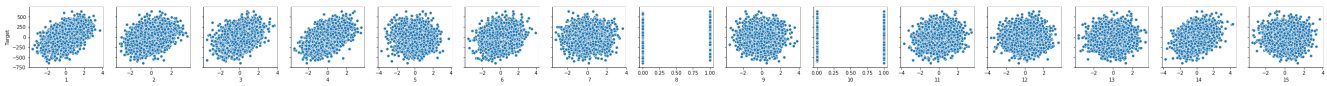




In [76]:

```
sns.pairplot(dataset, x_vars= features , y_vars='Target')

plt.show()
```



In [77]:

```
# Correlation univariate
(dataset[features].apply(lambda x: x.corr(dataset.Target)))
```

Out[77]:

```
1      0.464066
2      0.353172
3      0.376131
4      0.478007
5      0.026212
6      0.221729
7      0.026950
8      0.085570
9     -0.009050
10     0.005515
11     0.150283
12     0.031317
13     0.066465
14     0.347769
15    -0.011512
dtype: float64
```

That said, features data seems to match with the hypotesis standing at the base of a regression model. Moreover scaling is not necessary since the variables are already experssed in the same scale and distribute symmetrically.
We coud approach to this problem by training 3 models:

- An Ordinary Least Squares model (classic linear regression).
- A Random Forest Regression.
- A Support Vector Machines regression.

First, let's use our list of features to create the X matrix and the y vector:

In [78]:

```
# Divide the X matrix and target vector
X = dataset[features]
y = dataset['Target']
```

Since we have 4000 units, we can split the data set with a 3/4 ratio for training set and 1/3 for the leave-one-out testing set.
Then, training set will be cross validated in 3 fold of 1000 units each.

In [79]:

```
# Splitting the dataset into the Training set and Test set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25)
```

In [80]:

```
np.shape(X_test)
```

Out[80]:

```
(1000, 15)
```

Linear Regression Model

In [81]:

```
# LINEAR REGRESSION MODEL "lr"

regressor = LinearRegression()
parameters = {'fit_intercept':[True,False],
              'copy_X':[True, False]}

# Optimization & Cross Validation
gs_lr = GridSearchCV(regressor, parameters, cv=3)
gs_lr = gs_lr.fit(X_train,y_train)


print('***RESULTS***')
print("Best score: %f using %s" % (gs_lr.best_score_, gs_lr.best_params_))
means = gs_lr.cv_results_['mean_test_score']
stds = gs_lr.cv_results_['std_test_score']
params = gs_lr.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))

# Test
gs_lr.score(X_test, y_test)
```

```
***RESULTS***
Best score: 0.917599 using {'copy_X': True, 'fit_intercept': True}
0.917599 (0.005350) with: {'copy_X': True, 'fit_intercept': True}
0.914786 (0.005932) with: {'copy_X': True, 'fit_intercept': False}
0.917599 (0.005350) with: {'copy_X': False, 'fit_intercept': True}
0.914786 (0.005932) with: {'copy_X': False, 'fit_intercept': False}
```

Out[81]:

```
0.9232067792010106
```

Gridsearch Crossvalidation results tells us that this is the best setting for our regression model.
At this point we need to **train the optimal model on all the training data.**

In [82]:

```
# Optimal Linear Regression
regressor_opt = LinearRegression(copy_X = True, fit_intercept = True)
lr = regressor_opt.fit(X_train,y_train)
# Evaluation on Test Set via Mean Absolute Error
print("MAE train: ", mean_absolute_error(y_train, lr.predict(X_train)))
print("MAE test: ", mean_absolute_error(y_test, lr.predict(X_test)))
```

```
MAE train:  42.711722619276756
MAE test:  41.35863213431605
```

Since there is a good balance between train and test MAE, we could **rely on this model as it doesn't overfit.**

Random Forest Regression

The hyperparameters tuning for Random Forest can be computatioally expensive when using GridSearchCV, since all the different combinations of parameters are selected.
We want to use **RandomizedSearchCV** which select only a random of different combinations. This number is controlled by the "n_iter" parameter (we use 100 iters and 3 fold cross validations).

In [14]:

```python
# RANDOM FOREST 'rf'

regressor = RandomForestRegressor(random_state = 42)

parameters = {# resampling with or withut repcement
              'bootstrap': [True, False],
              # Maximum number of levels in tree
              'max_depth': [5, 10, 50, 100, None],
              # Number of features to consider at every split
              'max_features': ['auto', 'sqrt'],
              # Minimum number of samples required at each leaf node
              'min_samples_leaf': [1, 2, 4],
              # Minimum number of samples required to split a node
              'min_samples_split': [2, 5, 10],
              # Number of trees in random forest
              'n_estimators': [10, 50, 100, 500, 1000]}

gs_rf = RandomizedSearchCV(regressor, parameters, cv=3, n_iter = 100, verbose = 2)

gs_rf = gs_rf.fit(X_train,y_train)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
[CV] n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, bo
otstrap=True
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, bo
otstrap=True
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
```

```
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, bo
otstrap=True
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=50,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, boo
tstrap=True
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, boo
tstrap=True
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, boo
tstrap=True
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True, total=   0.0s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=None,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=None,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=None,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   0.3s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=True
```

```
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto,
max_depth=100, bootstrap=True, total=   7.7s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto,
max_depth=100, bootstrap=True, total=   7.8s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=auto,
max_depth=100, bootstrap=True, total=   7.8s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   1.2s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   1.2s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   1.2s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, bo
otstrap=False
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, bo
otstrap=False
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, bo
otstrap=False
[CV]  n_estimators=10, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.3s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.3s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.3s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, b
ootstrap=False, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, b
ootstrap=False, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=1, max_features=sqrt, max_depth=5, b
ootstrap=False, total=   0.0s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.1s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.1s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.1s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   4.2s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt
```

```
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   4.2s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=1, max_features=sqrt,
max_depth=None, bootstrap=False, total=   4.2s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False, total=   3.6s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False, total=   3.5s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=4, max_features=sqrt,
max_depth=None, bootstrap=False, total=   3.6s
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bootstrap=False, total=   0.2s
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bootstrap=False, total=   0.2s
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```

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ootstrap=True, total=   2.4s
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bootstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=sqrt, max_depth=10, b
```

```
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bootstrap=True
```

```
bootstrap=True
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[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
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```

```
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```

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```

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[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.2s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.2s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=50,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=50, bootstrap=True, total=   2.3s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=50,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=50, bootstrap=True, total=   2.3s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=50,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=50, bootstrap=True, total=   2.4s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bo
otstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bo
otstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bo
otstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, b
ootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10, b
ootstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto,
```

```
max_depth=100, bootstrap=False, total=   1.3s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto,
max_depth=100, bootstrap=False, total=   1.3s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto,
max_depth=100, bootstrap=False, total=   1.2s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True, total=   2.3s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True, total=   2.3s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=4, max_features=sqrt,
max_depth=100, bootstrap=True, total=   2.3s
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max_depth=100, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=2, max_features=auto,
max_depth=100, bootstrap=False, total=  13.4s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=2, max_features=auto,
max_depth=100, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=2, max_features=auto,
max_depth=100, bootstrap=False, total=  13.4s
[CV] n_estimators=1000, min_samples_split=10, min_samples_leaf=2, max_features=auto,
max_depth=100, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=10, min_samples_leaf=2, max_features=auto,
max_depth=100, bootstrap=False, total=  13.6s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=10,
bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=10,
bootstrap=True, total=   3.7s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=10,
bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=10,
bootstrap=True, total=   3.6s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=10,
bootstrap=True
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bootstrap=True, total=   3.8s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5,
bootstrap=False, total=   0.7s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5,
bootstrap=False, total=   0.8s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5, b
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[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=5,
bootstrap=False, total=   0.8s
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otstrap=False
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=50, bo
otstrap=False
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=50, bo
otstrap=False
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=50, b
ootstrap=False, total=   0.0s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5, b
ootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5,
bootstrap=False, total=   2.2s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5, b
ootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5,
bootstrap=False, total=   2.2s
```

```
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5, b
ootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5,
bootstrap=False, total=   2.3s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=500, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   4.1s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
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bootstrap=True, total=   4.1s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=500, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   4.1s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=False, total=   0.2s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=False, total=   0.2s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=sqrt, max_depth=10,
bootstrap=False, total=   0.2s
[CV] n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   2.5s
[CV] n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   2.5s
[CV] n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True
[CV]  n_estimators=1000, min_samples_split=2, min_samples_leaf=2, max_features=sqrt, max_depth=10,
bootstrap=True, total=   2.5s
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tstrap=False
[CV]  n_estimators=50, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False, total=   0.3s
[CV] n_estimators=50, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=5, boo
tstrap=False
[CV]  n_estimators=50, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False, total=   0.3s
[CV] n_estimators=50, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=5, boo
tstrap=False
[CV]  n_estimators=50, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.7s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.7s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.7s
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bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=2, max_features=auto, max_depth=10,
bootstrap=True, total=   3.8s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=2, max_features=auto, max_depth=10,
bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=2, max_features=auto, max_depth=10,
bootstrap=True, total=   3.7s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=2, max_features=auto, max_depth=10,
bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=2, max_features=auto, max_depth=10,
bootstrap=True, total=   3.7s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
```

```
bootstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
bootstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
bootstrap=True
[CV]  n_estimators=10, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=None,
bootstrap=True, total=   0.0s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5,
bootstrap=False, total=   0.1s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=False
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bootstrap=False, total=   0.1s
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ootstrap=False
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bootstrap=False, total=   0.1s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=False
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bootstrap=False, total=   1.1s
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ootstrap=False
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bootstrap=False, total=   1.1s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
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[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5,
bootstrap=False, total=   1.1s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=5,
bootstrap=False, total=   4.0s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=5,
bootstrap=False, total=   3.8s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=5, b
ootstrap=False
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bootstrap=False, total=   3.9s
[CV] n_estimators=50, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=50, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=50, b
ootstrap=False, total=   0.7s
[CV] n_estimators=50, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=50, bo
otstrap=False
[CV]  n_estimators=50, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=50, b
ootstrap=False, total=   0.7s
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otstrap=False
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[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5, b
ootstrap=True
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bootstrap=True, total=   1.5s
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ootstrap=True
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bootstrap=True, total=   1.6s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5, b
ootstrap=True
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=5,
bootstrap=True, total=   1.6s
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ootstrap=False
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=100,
bootstrap=False, total=   0.1s
[CV] n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=100, b
ootstrap=False
```

```
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False, total=   0.1s
[CV] n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False
[CV]  n_estimators=50, min_samples_split=5, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False, total=   0.1s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bootstrap=True
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bootstrap=True, total=   0.6s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=4, max_features=auto, max_depth=10, bootstrap=True
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[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True, total=   0.8s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True, total=   0.8s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, bootstrap=True, total=   0.8s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=auto, max_depth=100, bootstrap=False
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[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=auto, max_depth=100, bootstrap=False, total=  14.9s
[CV] n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=auto, max_depth=100, bootstrap=False
[CV]  n_estimators=1000, min_samples_split=5, min_samples_leaf=2, max_features=auto, max_depth=100, bootstrap=False, total=  14.7s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False, total=   0.3s
[CV] n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False
[CV]  n_estimators=100, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=100, bootstrap=False, total=   0.3s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True, total=   3.7s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True, total=   3.8s
[CV] n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True
[CV]  n_estimators=500, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=None, bootstrap=True, total=   3.9s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10, bootstrap=False
[CV]  n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10, bootstrap=False, total=   1.8s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10, bootstrap=False
[CV]  n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10, bootstrap=False, total=   1.7s
[CV] n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10, bootstrap=False
[CV]  n_estimators=500, min_samples_split=5, min_samples_leaf=2, max_features=sqrt, max_depth=10,
```

```
bootstrap=False, total=   1.7s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=True, total=   0.0s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, bo
otstrap=True
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=sqrt, max_depth=5, b
ootstrap=True, total=   0.0s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.8s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.7s
[CV] n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, bo
otstrap=False
[CV]  n_estimators=100, min_samples_split=5, min_samples_leaf=1, max_features=auto, max_depth=5, b
ootstrap=False, total=   0.7s
[CV] n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   4.2s
[CV] n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   4.2s
[CV] n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=500, min_samples_split=2, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   4.2s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   0.6s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   0.6s
[CV] n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50, b
ootstrap=False
[CV]  n_estimators=50, min_samples_split=10, min_samples_leaf=4, max_features=auto, max_depth=50,
bootstrap=False, total=   0.5s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10, b
ootstrap=True
[CV]  n_estimators=10, min_samples_split=10, min_samples_leaf=1, max_features=auto, max_depth=10,
bootstrap=True, total=   0.0s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False, total=   1.3s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False, total=   1.3s
[CV] n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False
[CV]  n_estimators=100, min_samples_split=2, min_samples_leaf=4, max_features=auto, max_depth=100,
bootstrap=False, total=   1.2s
```

```
[Parallel(n_jobs=1)]: Done 300 out of 300 | elapsed: 10.5min finished
```

```
***RESULTS***
Best score: 0.794051 using {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2, '
max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.717360 (0.005330) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.695613 (0.020369) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.562817 (0.004159) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.768397 (0.007626) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.785475 (0.013409) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': True}
0.515635 (0.021378) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.725048 (0.012192) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.460115 (0.023649) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.571825 (0.009790) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.726727 (0.005728) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.772707 (0.006999) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.755658 (0.006834) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.780320 (0.014946) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.737514 (0.007335) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.691157 (0.014361) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.794051 (0.012424) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.662767 (0.016090) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.662796 (0.016140) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.559630 (0.010398) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.560863 (0.008006) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.516013 (0.019865) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm
ax_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.793428 (0.012055) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.515944 (0.020097) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 2, 'ma
x_features': 'auto', 'max_depth': None, 'bootstrap': False}
0.748514 (0.008599) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.717185 (0.013626) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.781417 (0.013456) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': True}
0.460137 (0.023646) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 1, '
max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.749253 (0.006131) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 1, '
max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.755458 (0.006408) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.741244 (0.005148) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, '
max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.741509 (0.006118) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, '
max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.659791 (0.019601) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.760476 (0.006452) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm
ax_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.741439 (0.005289) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.740010 (0.005096) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.523238 (0.027727) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, '
max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
```

max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.496960 (0.023698) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.505827 (0.026714) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.637055 (0.017356) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.731545 (0.007233) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.753375 (0.005666) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.503714 (0.027978) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.758360 (0.014458) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.521241 (0.024680) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.719512 (0.010996) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.753356 (0.014555) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.736763 (0.008890) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.772756 (0.006763) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.492533 (0.026605) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.736763 (0.008890) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.785224 (0.013359) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.654996 (0.020113) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.721113 (0.004253) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.744884 (0.007984) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.573302 (0.007074) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.746102 (0.006159) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.460240 (0.023786) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.637082 (0.017657) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.786017 (0.014983) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.787224 (0.013023) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.740010 (0.005096) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.506896 (0.028651) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.576672 (0.007227) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.735490 (0.007241) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.754784 (0.013916) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.728541 (0.006396) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.513689 (0.022584) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.515985 (0.019785) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.779976 (0.013306) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.460139 (0.023646) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.714337 (0.002398) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.578503 (0.006899) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}

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0.787586 (0.012360) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.737514 (0.007335) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.739304 (0.004869) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.458380 (0.024392) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.458380 (0.024392) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.783290 (0.012758) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm
ax_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.710554 (0.009168) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.572340 (0.007583) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.577208 (0.007160) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.458380 (0.024392) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.498068 (0.024169) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.587832 (0.003242) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.748831 (0.006023) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.778912 (0.013455) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.785768 (0.013304) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.492533 (0.026605) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.751992 (0.008303) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.782645 (0.013496) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.748654 (0.006409) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.584457 (0.006809) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.460246 (0.023785) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.787896 (0.012365) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.523238 (0.027759) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.752420 (0.020440) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.515635 (0.021378) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
```

Out[14]:

```
0.8097357373823227
```

In [17]:

```
print('***RESULTS***')
print("Best score: %f using %s" % (gs_rf.best_score_, gs_rf.best_params_))
means = gs_rf.cv_results_['mean_test_score']
stds = gs_rf.cv_results_['std_test_score']
params = gs_rf.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

```
***RESULTS***
Best score: 0.794051 using {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2, '
max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.717360 (0.005330) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.695613 (0.020369) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.562817 (0.004159) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.768397 (0.007626) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
```

'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.785475 (0.013409) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': True}
0.515635 (0.021378) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.725048 (0.012192) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.460115 (0.023649) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.571825 (0.009790) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.726727 (0.005728) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.772707 (0.006999) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.755658 (0.006834) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.780320 (0.014946) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.737514 (0.007335) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.691157 (0.014361) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.794051 (0.012424) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.662767 (0.016090) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.662796 (0.016140) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.559630 (0.010398) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.560863 (0.008006) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.516013 (0.019865) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.793428 (0.012055) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.515944 (0.020097) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': None, 'bootstrap': False}
0.748514 (0.008599) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.717185 (0.013626) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': False}
0.781417 (0.013456) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': True}
0.460137 (0.023646) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.749253 (0.006131) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 1, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.755458 (0.006408) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.741244 (0.005148) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.741509 (0.006118) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.659791 (0.019601) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.760476 (0.006452) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.741439 (0.005289) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.740010 (0.005096) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.523238 (0.027727) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, 'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.496960 (0.023698) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1, 'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.505827 (0.026714) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.637055 (0.017356) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.731545 (0.007233) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 4, 'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.753375 (0.005666) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 2, 'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}

0.503714 (0.027978) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.758360 (0.014458) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.521241 (0.024680) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 1, 'm
ax_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.719512 (0.010996) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.753356 (0.014555) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.736763 (0.008890) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.772756 (0.006763) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.492533 (0.026605) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.736763 (0.008890) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.785224 (0.013359) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.654996 (0.020113) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.721113 (0.004253) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 2, 'ma
x_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.744884 (0.007984) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.573302 (0.007074) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.746102 (0.006159) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 1, 'm
ax_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.460240 (0.023786) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.637082 (0.017657) with: {'n_estimators': 10, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': True}
0.786017 (0.014983) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': True}
0.787224 (0.013023) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm
ax_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.740010 (0.005096) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.506896 (0.028651) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': False}
0.576672 (0.007227) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm
ax_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.735490 (0.007241) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, '
max_features': 'sqrt', 'max_depth': 50, 'bootstrap': True}
0.754784 (0.013916) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.728541 (0.006396) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 2, 'ma
x_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.513689 (0.022584) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 1, 'm
ax_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.738011 (0.006398) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 4, '
max_features': 'sqrt', 'max_depth': 100, 'bootstrap': True}
0.515985 (0.019785) with: {'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 2, '
max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.779976 (0.013306) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.460139 (0.023646) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 1, 'm
ax_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.714337 (0.002398) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 50, 'bootstrap': False}
0.578503 (0.006899) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.787586 (0.012360) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.737514 (0.007335) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.739304 (0.004869) with: {'n_estimators': 1000, 'min_samples_split': 2, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': True}
0.458380 (0.024392) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.458380 (0.024392) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.783290 (0.012758) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 2, 'm

```
ax_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.710554 (0.009168) with: {'n_estimators': 10, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': None, 'bootstrap': True}
0.572340 (0.007583) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.577208 (0.007160) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 5, 'bootstrap': False}
0.458380 (0.024392) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.498068 (0.024169) with: {'n_estimators': 50, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.587832 (0.003242) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.748831 (0.006023) with: {'n_estimators': 50, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.778912 (0.013455) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.785768 (0.013304) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.492533 (0.026605) with: {'n_estimators': 1000, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
0.751992 (0.008303) with: {'n_estimators': 100, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'sqrt', 'max_depth': 100, 'bootstrap': False}
0.782645 (0.013496) with: {'n_estimators': 500, 'min_samples_split': 10, 'min_samples_leaf': 4, 'm
ax_features': 'auto', 'max_depth': None, 'bootstrap': True}
0.748654 (0.006409) with: {'n_estimators': 500, 'min_samples_split': 5, 'min_samples_leaf': 2,
'max_features': 'sqrt', 'max_depth': 10, 'bootstrap': False}
0.584457 (0.006809) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'sqrt', 'max_depth': 5, 'bootstrap': True}
0.460246 (0.023785) with: {'n_estimators': 100, 'min_samples_split': 5, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 5, 'bootstrap': False}
0.787896 (0.012365) with: {'n_estimators': 500, 'min_samples_split': 2, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.523238 (0.027759) with: {'n_estimators': 50, 'min_samples_split': 10, 'min_samples_leaf': 4, 'ma
x_features': 'auto', 'max_depth': 50, 'bootstrap': False}
0.752420 (0.020440) with: {'n_estimators': 10, 'min_samples_split': 10, 'min_samples_leaf': 1, 'ma
x_features': 'auto', 'max_depth': 10, 'bootstrap': True}
0.515635 (0.021378) with: {'n_estimators': 100, 'min_samples_split': 2, 'min_samples_leaf': 4,
'max_features': 'auto', 'max_depth': 100, 'bootstrap': False}
```

In [83]:

```
# Optimal Random Forest
random_opt = RandomForestRegressor(n_estimators=1000,
                                   min_samples_split=2,
                                   min_samples_leaf=2,
                                   max_features='auto',
                                   max_depth=50,
                                   bootstrap=True)
rf = random_opt.fit(X_train,y_train)
# Evaluation on Test Set via Mean Absolute Error
print("MAE train: ", mean_absolute_error(y_train, rf.predict(X_train)))
print("MAE test: ", mean_absolute_error(y_test, rf.predict(X_test)))
```

```
MAE train:  26.40923572374659
MAE test:  62.456777222652676
```

However, The Random Forest is overfitting the data, as there is too much differenct between Training set MAE and Testing set MAE.

Support Vector Machines Regression

In this case we will try to find the optimal value of "C". A smaller value of **C increases the margin of the hyperplane** while larger values reduce it.
Instead the value of **"epsilon" defines a margin of tolerance for the errors**: the larger "epsilon" is, the larger errors you admit in your solution.

In [84]:

```
# SVR  'sv'

regressor = SVR()
parameters = {'kernel': ('linear', 'rbf','poly'),
```

```
              'C':[1.5, 10],
              'gamma': [1e-7, 1e-4],
              'epsilon':[0.1,0.2,0.5,0.3]}

#DEFINE YOUR GRIDSEARCH
gs_sv = GridSearchCV(regressor, parameters, cv=3, verbose = 2) #with no params it reduces to a CV

gs_sv = gs_sv.fit(X_train,y_train)
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Fitting 3 folds for each of 48 candidates, totalling 144 fits
[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear ..................
[CV] ... C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear, total=   0.0s
[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear ..................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s

[CV] ... C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear, total=   0.0s
[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear ..................
[CV] ... C=1.5, epsilon=0.1, gamma=1e-07, kernel=linear, total=   0.0s
[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=rbf .....................
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[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=rbf .....................
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[CV] C=1.5, epsilon=0.1, gamma=1e-07, kernel=poly ....................
[CV] ..... C=1.5, epsilon=0.1, gamma=1e-07, kernel=poly, total=   0.0s
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[CV] C=1.5, epsilon=0.1, gamma=0.0001, kernel=linear .................
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[CV] C=1.5, epsilon=0.1, gamma=0.0001, kernel=rbf ....................
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[CV] C=1.5, epsilon=0.3, gamma=0.0001, kernel=poly ....................
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[CV] .... C=1.5, epsilon=0.3, gamma=0.0001, kernel=poly, total=   0.0s
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[CV] ...... C=10, epsilon=0.5, gamma=1e-07, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.5, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.5, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.5, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.5, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.5, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.5, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.5, gamma=0.0001, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.5, gamma=0.0001, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.5, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.5, gamma=0.0001, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=linear ...................
[CV] .... C=10, epsilon=0.3, gamma=1e-07, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=linear ...................
[CV] .... C=10, epsilon=0.3, gamma=1e-07, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=linear ...................
[CV] .... C=10, epsilon=0.3, gamma=1e-07, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=rbf ......................
[CV] ....... C=10, epsilon=0.3, gamma=1e-07, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=rbf ......................
[CV] ....... C=10, epsilon=0.3, gamma=1e-07, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=rbf ......................
[CV] ....... C=10, epsilon=0.3, gamma=1e-07, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=poly .....................
[CV] ...... C=10, epsilon=0.3, gamma=1e-07, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=poly .....................
[CV] ...... C=10, epsilon=0.3, gamma=1e-07, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=1e-07, kernel=poly .....................
[CV] ...... C=10, epsilon=0.3, gamma=1e-07, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.3, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.3, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=linear ..................
[CV] ... C=10, epsilon=0.3, gamma=0.0001, kernel=linear, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.3, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.3, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=rbf .....................
[CV] ...... C=10, epsilon=0.3, gamma=0.0001, kernel=rbf, total=   0.1s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.3, gamma=0.0001, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.3, gamma=0.0001, kernel=poly, total=   0.0s
[CV] C=10, epsilon=0.3, gamma=0.0001, kernel=poly .....................
[CV] ..... C=10, epsilon=0.3, gamma=0.0001, kernel=poly, total=   0.0s

[Parallel(n_jobs=1)]: Done 144 out of 144 | elapsed:   30.7s finished
```

In [85]:

```
#summarize the results of your GRIDSEARCH
print('***GRIDSEARCH RESULTS***')
print("Best score: %f using %s" % (gs_sv.best_score_, gs_sv.best_params_))
means = gs_sv.cv_results_['mean_test_score']
stds = gs_sv.cv_results_['std_test_score']
params = gs_sv.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))

#Returns the coefficient of determination R^2 of the prediction.
#Explained variance score: 1 is perfect prediction
gs_sv.score(X_test, y_test)
```

```
***GRIDSEARCH RESULTS***
Best score: 0.917261 using {'C': 10, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'linear'}
0.916722 (0.004479) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001716 (0.002219) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001720 (0.002219) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'poly'}
0.916722 (0.004479) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'linear'}
0.002861 (0.002272) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001720 (0.002219) with: {'C': 1.5, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'poly'}
0.916705 (0.004471) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001698 (0.002198) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001703 (0.002198) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'poly'}
0.916705 (0.004471) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'linear'}
0.002882 (0.002234) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001703 (0.002198) with: {'C': 1.5, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'poly'}
0.916719 (0.004456) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001662 (0.002158) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001667 (0.002158) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'poly'}
0.916719 (0.004456) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'linear'}
0.002912 (0.002170) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001667 (0.002158) with: {'C': 1.5, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'poly'}
0.916717 (0.004455) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001670 (0.002166) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001674 (0.002166) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'poly'}
0.916717 (0.004455) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'linear'}
0.002886 (0.002221) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001674 (0.002166) with: {'C': 1.5, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'poly'}
0.917261 (0.005094) with: {'C': 10, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001689 (0.002219) with: {'C': 10, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001720 (0.002219) with: {'C': 10, 'epsilon': 0.1, 'gamma': 1e-07, 'kernel': 'poly'}
0.917261 (0.005094) with: {'C': 10, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'linear'}
0.028596 (0.002360) with: {'C': 10, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001720 (0.002219) with: {'C': 10, 'epsilon': 0.1, 'gamma': 0.0001, 'kernel': 'poly'}
0.917247 (0.005118) with: {'C': 10, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001672 (0.002199) with: {'C': 10, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001703 (0.002198) with: {'C': 10, 'epsilon': 0.2, 'gamma': 1e-07, 'kernel': 'poly'}
0.917247 (0.005118) with: {'C': 10, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'linear'}
0.028583 (0.002375) with: {'C': 10, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001703 (0.002198) with: {'C': 10, 'epsilon': 0.2, 'gamma': 0.0001, 'kernel': 'poly'}
0.917232 (0.005092) with: {'C': 10, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001636 (0.002158) with: {'C': 10, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001667 (0.002158) with: {'C': 10, 'epsilon': 0.5, 'gamma': 1e-07, 'kernel': 'poly'}
0.917232 (0.005092) with: {'C': 10, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'linear'}
0.028543 (0.002413) with: {'C': 10, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001667 (0.002158) with: {'C': 10, 'epsilon': 0.5, 'gamma': 0.0001, 'kernel': 'poly'}
0.917256 (0.005106) with: {'C': 10, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'linear'}
-0.001644 (0.002166) with: {'C': 10, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'rbf'}
-0.001674 (0.002166) with: {'C': 10, 'epsilon': 0.3, 'gamma': 1e-07, 'kernel': 'poly'}
0.917256 (0.005106) with: {'C': 10, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'linear'}
0.028560 (0.002412) with: {'C': 10, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'rbf'}
-0.001674 (0.002166) with: {'C': 10, 'epsilon': 0.3, 'gamma': 0.0001, 'kernel': 'poly'}
```

Out[85]:

```
0.9227266795554477
```

In [86]:

```
# Fitting the optimanl SVR
svm_opt = SVR(C= 10,
              epsilon = 0.1,
```

```
            gamma = 1e-07,
            kernel = 'linear')

svm_mod = svm_opt.fit(X_train, y_train)
# THIS ASSIGNMENT IS EVALUAED ON MAE
print("MAE train: ", mean_absolute_error(y_train, svm_mod.predict(X_train)))
print("MAE test: ", mean_absolute_error(y_test, svm_mod.predict(X_test)))
```

```
MAE train:  42.635314644122765
MAE test:  41.44187874340376
```

The results of the 3 models suggests that:

- Linear Regression and SVR have similar Mean Absolute Errors.
- Both Linear Regression and SVR don't overfit the data, as the difference between training and testing MAE is small.
- Random Forest performs better on training set, but is less generalizable on testing data.

Unlabeled Data Prediction

Since Linear Regressiona and SVR have similar performance, I will prefer to use Linear Regression for this task as it's less complex and more generalizable one. Let's import the unlabeled dataset:

In [132]:

```
# Read CSV and print testset shape
validation = pd.read_csv('Data_Regression_Test_Unlabeled.csv')
print('Data_Regression_Test_Unlabeled.csv')
print(validation.shape)
#dataset.head()
```

```
Data_Regression_Test_Unlabeled.csv
(8000, 15)
```

In [133]:

```
validation.head()
```

Out[133]:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0	0.068260	-1.109403	-0.210382	0.175201	0.267580	-0.395031	0.256556	1	1.964220	1	-1.439576	0.272552	0.203683	0.390998	0.5
1	-0.261958	-1.577900	0.501939	-1.761268	-0.402250	-1.230560	-0.043696	1	-0.424752	1	0.251492	-0.913980	1.319460	-0.157462	0.4
2	-0.959060	0.198293	-0.561824	-2.287285	-1.293155	-1.161634	0.442543	0	0.583780	1	-2.186017	-1.329723	2.045052	-0.677397	0.0
3	-0.577453	0.868575	0.240723	1.352240	-0.348857	0.237448	-0.551082	1	0.601101	1	-0.077819	0.833521	-0.049008	0.132320	1.4
4	-0.759606	-1.373947	-1.202349	-1.031986	1.909736	0.149477	0.680694	1	2.005299	0	1.313171	0.491434	0.316489	-0.806792	0.9

In [134]:

```
# Prediction
prediction = lr.predict(validation)
prediction
validation['Prediction'] = prediction
validation.head()
```

Out[134]:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0	0.068260	-1.109403	-0.210382	0.175201	0.267580	-0.395031	0.256556	1	1.964220	1	-1.439576	0.272552	0.203683	0.390998	0.5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	0.261958	1.577900	0.501939	1.761268	0.402250	1.230560	0.043696	1	0.424752	1	0.251492	0.913980	1.319460	0.157462	0.4
2	-0.959060	0.198293	-0.561824	-2.287285	-1.293155	-1.161634	0.442543	0	0.583780	1	-2.186017	-1.329723	2.045052	-0.677397	0.0
3	-0.577453	0.868575	0.240723	1.352240	-0.348857	0.237448	-0.551082	1	0.601101	1	-0.077819	0.833521	-0.049008	0.132320	1.4
4	-0.759606	-1.373947	-1.202349	-1.031986	1.909736	0.149477	0.680694	1	2.005299	0	1.313171	0.491434	0.316489	-0.806792	0.9

In [135]:

```
print(validation.shape)
```

```
(8000, 16)
```

In [138]:

```
col_to_save = validation['Prediction']
col_to_save.shape
```

Out[138]:

```
(8000,)
```

In [139]:

```
col_to_save.to_csv('892277.csv',sep=',')
```