In [193]:

```
#                                                    LIBRARIES
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import mglearn as mglearn
import graphviz
import pprint

from sklearn.datasets import load_wine
from sklearn.preprocessing import OneHotEncoder
from IPython.display import Image
from sklearn import datasets
from mglearn.datasets import make_blobs
from sklearn.svm import SVC

from sklearn.model_selection import LeaveOneOut
from sklearn.model_selection import train_test_split, KFold
from sklearn.model_selection import RandomizedSearchCV, cross_va
l_score, GridSearchCV
from sklearn.tree import DecisionTreeClassifier, DecisionTreeReg
ressor, export_graphviz
from sklearn.linear_model import LinearRegression, LogisticRegre
ssion

from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor


from sklearn.metrics import classification_report, confusion_mat
rix
```

In [20]:

```
pp = pprint.PrettyPrinter(indent=4)
wine = load_wine()
logreg = LogisticRegression()
```

In [45]:

```
#Structuring wine dataset
print(wine.DESCR)
wine = datasets.load_wine()
df = pd.DataFrame(wine.data,columns=wine.feature_names)
print(df)
```

```
Wine Data Database
====================

Notes
-----
Data Set Characteristics:
    :Number of Instances: 178 (50 in each of three c
lasses)
    :Number of Attributes: 13 numeric, predictive at
tributes and the class
    :Attribute Information:
                - 1) Alcohol
                - 2) Malic acid
                - 3) Ash
                - 4) Alcalinity of ash
                - 5) Magnesium
                - 6) Total phenols
                - 7) Flavanoids
                - 8) Nonflavanoid phenols
                - 9) Proanthocyanins
                - 10)Color intensity
                - 11)Hue
                - 12)OD280/OD315 of diluted wines
                - 13)Proline
                - class:
                - class_0
                - class_1
                - class_2

    :Summary Statistics:

    ============================== ==== ===== =======
=====
                                      Min   Max   Mean
SD
    ============================== ==== ===== =======
```

```
=====
    Alcohol:                      11.0  14.8    13.0
0.8
    Malic Acid:                   0.74  5.80    2.34
1.12
    Ash:                          1.36  3.23    2.36
0.27
    Alcalinity of Ash:            10.6  30.0    19.5
3.3
    Magnesium:                    70.0 162.0    99.7
14.3
    Total Phenols:                0.98  3.88    2.29
0.63
    Flavanoids:                   0.34  5.08    2.03
1.00
    Nonflavanoid Phenols:         0.13  0.66    0.36
0.12
    Proanthocyanins:              0.41  3.58    1.59
0.57
    Colour Intensity:              1.3  13.0     5.1
2.3
    Hue:                          0.48  1.71    0.96
0.23
    OD280/OD315 of diluted wines: 1.27  4.00    2.61
0.71
    Proline:                       278  1680     746
315
    ============================ ==== ===== =======
=====

    :Missing Attribute Values: None
    :Class Distribution: class_0 (59), class_1 (71),
class_2 (48)
    :Creator: R.A. Fisher
    :Donor: Michael Marshall (MARSHALL%PLU@io.arc.na
sa.gov)
    :Date: July, 1988

This is a copy of UCI ML Wine recognition datasets.
https://archive.ics.uci.edu/ml/machine-learning-data
bases/wine/wine.data

The data is the results of a chemical analysis of wi
nes grown in the same
region in Italy by three different cultivators. Ther
```

e are thirteen different
measurements taken for different constituents found
in the three types of
wine.

Original Owners:

Forina, M. et al, PARVUS -
An Extendible Package for Data Exploration, Classifi
cation and Correlation.
Institute of Pharmaceutical and Food Analysis and Te
chnologies,
Via Brigata Salerno, 16147 Genoa, Italy.

Citation:

Lichman, M. (2013). UCI Machine Learning Repository
[http://archive.ics.uci.edu/ml]. Irvine, CA: Univers
ity of California,
School of Information and Computer Science.

References
----
(1)
S. Aeberhard, D. Coomans and O. de Vel,
Comparison of Classifiers in High Dimensional Settin
gs,
Tech. Rep. no. 92-02, (1992), Dept. of Computer Scie
nce and Dept. of
Mathematics and Statistics, James Cook University of
North Queensland.
(Also submitted to Technometrics).

The data was used with many others for comparing var
ious
classifiers. The classes are separable, though only
RDA
has achieved 100% correct classification.
(RDA : 100%, QDA 99.4%, LDA 98.9%, 1NN 96.1% (z-tran
sformed data))
(All results using the leave-one-out technique)

(2)
S. Aeberhard, D. Coomans and O. de Vel,
"THE CLASSIFICATION PERFORMANCE OF RDA"

Tech. Rep. no. 92-01, (1992), Dept. of Computer Scie
nce and Dept. of
Mathematics and Statistics, James Cook University of
North Queensland.
(Also submitted to Journal of Chemometrics).

	alcohol	malic_acid	ash	alcalinity_of_ash	magnesium	total_phenols	\
0	14.23	1.71	2.43	15.6	127.0	2.80	
1	13.20	1.78	2.14	11.2	100.0	2.65	
2	13.16	2.36	2.67	18.6	101.0	2.80	
3	14.37	1.95	2.50	16.8	113.0	3.85	
4	13.24	2.59	2.87	21.0	118.0	2.80	
5	14.20	1.76	2.45	15.2	112.0	3.27	
6	14.39	1.87	2.45	14.6	96.0	2.50	
7	14.06	2.15	2.61	17.6	121.0	2.60	
8	14.83	1.64	2.17	14.0	97.0	2.80	
9	13.86	1.35	2.27	16.0	98.0	2.98	
10	14.10	2.16	2.30	18.0	105.0	2.95	
11	14.12	1.48	2.32	16.8	95.0	2.20	
12	13.75	1.73	2.41	16.0	89.0	2.60	
13	14.75	1.73	2.39	11.4	91.0	3.10	
14	14.38	1.87	2.38	12.0	102.0	3.30	
15	13.63	1.81	2.70	17.2	112.0	2.85	
16	14.30	1.92	2.72	20.0	120.0	2.80	
17	13.83	1.57	2.62	20.0	115.0	2.95	
18	14.19	1.59	2.48	16.5			

```
108.0            3.30
19     13.64         3.10  2.56              15.2
116.0            2.70
20     14.06         1.63  2.28              16.0
126.0            3.00
21     12.93         3.80  2.65              18.6
102.0            2.41
22     13.71         1.86  2.36              16.6
101.0            2.61
23     12.85         1.60  2.52              17.8
95.0           2.48
24     13.50         1.81  2.61              20.0
96.0           2.53
25     13.05         2.05  3.22              25.0
124.0            2.63
26     13.39         1.77  2.62              16.1
93.0           2.85
27     13.30         1.72  2.14              17.0
94.0           2.40
28     13.87         1.90  2.80              19.4
107.0            2.95
29     14.02         1.68  2.21              16.0
96.0           2.65
..       ...          ...   ...               ...
...            ...
148    13.32         3.24  2.38              21.5
92.0           1.93
149    13.08         3.90  2.36              21.5
113.0            1.41
150    13.50         3.12  2.62              24.0
123.0            1.40
151    12.79         2.67  2.48              22.0
112.0            1.48
152    13.11         1.90  2.75              25.5
116.0            2.20
153    13.23         3.30  2.28              18.5
98.0           1.80
154    12.58         1.29  2.10              20.0
103.0            1.48
155    13.17         5.19  2.32              22.0
93.0           1.74
156    13.84         4.12  2.38              19.5
89.0           1.80
157    12.45         3.03  2.64              27.0
97.0           1.90
```

```
158    14.34         1.68  2.70               25.0
98.0           2.80
159    13.48         1.67  2.64               22.5
89.0           2.60
160    12.36         3.83  2.38               21.0
88.0           2.30
161    13.69         3.26  2.54               20.0
107.0           1.83
162    12.85         3.27  2.58               22.0
106.0           1.65
163    12.96         3.45  2.35               18.5
106.0           1.39
164    13.78         2.76  2.30               22.0
90.0           1.35
165    13.73         4.36  2.26               22.5
88.0           1.28
166    13.45         3.70  2.60               23.0
111.0           1.70
167    12.82         3.37  2.30               19.5
88.0           1.48
168    13.58         2.58  2.69               24.5
105.0           1.55
169    13.40         4.60  2.86               25.0
112.0           1.98
170    12.20         3.03  2.32               19.0
96.0           1.25
171    12.77         2.39  2.28               19.5
86.0           1.39
172    14.16         2.51  2.48               20.0
91.0           1.68
173    13.71         5.65  2.45               20.5
95.0           1.68
174    13.40         3.91  2.48               23.0
102.0           1.80
175    13.27         4.28  2.26               20.0
120.0           1.59
176    13.17         2.59  2.37               20.0
120.0           1.65
177    14.13         4.10  2.74               24.5
96.0           2.05

     flavanoids  nonflavanoid_phenols  proanthocyani
ns  color_intensity   hue  \
0          3.06                  0.28            2.
29         5.640000  1.04
```

1 2.76 0.26 1.
28 4.380000 1.05
2 3.24 0.30 2.
81 5.680000 1.03
3 3.49 0.24 2.
18 7.800000 0.86
4 2.69 0.39 1.
82 4.320000 1.04
5 3.39 0.34 1.
97 6.750000 1.05
6 2.52 0.30 1.
98 5.250000 1.02
7 2.51 0.31 1.
25 5.050000 1.06
8 2.98 0.29 1.
98 5.200000 1.08
9 3.15 0.22 1.
85 7.220000 1.01
10 3.32 0.22 2.
38 5.750000 1.25
11 2.43 0.26 1.
57 5.000000 1.17
12 2.76 0.29 1.
81 5.600000 1.15
13 3.69 0.43 2.
81 5.400000 1.25
14 3.64 0.29 2.
96 7.500000 1.20
15 2.91 0.30 1.
46 7.300000 1.28
16 3.14 0.33 1.
97 6.200000 1.07
17 3.40 0.40 1.
72 6.600000 1.13
18 3.93 0.32 1.
86 8.700000 1.23
19 3.03 0.17 1.
66 5.100000 0.96
20 3.17 0.24 2.
10 5.650000 1.09
21 2.41 0.25 1.
98 4.500000 1.03
22 2.88 0.27 1.
69 3.800000 1.11
23 2.37 0.26 1.

```
46          3.930000  1.09
24          2.61                0.28            1.
66          3.520000  1.12
25          2.68                0.47            1.
92          3.580000  1.13
26          2.94                0.34            1.
45          4.800000  0.92
27          2.19                0.27            1.
35          3.950000  1.02
28          2.97                0.37            1.
76          4.500000  1.25
29          2.33                0.26            1.
98          4.700000  1.04
..           ...                 ...             .
..              ...   ...
148         0.76                0.45            1.
25          8.420000  0.55
149         1.39                0.34            1.
14          9.400000  0.57
150         1.57                0.22            1.
25          8.600000  0.59
151         1.36                0.24            1.
26         10.800000  0.48
152         1.28                0.26            1.
56          7.100000  0.61
153         0.83                0.61            1.
87         10.520000  0.56
154         0.58                0.53            1.
40          7.600000  0.58
155         0.63                0.61            1.
55          7.900000  0.60
156         0.83                0.48            1.
56          9.010000  0.57
157         0.58                0.63            1.
14          7.500000  0.67
158         1.31                0.53            2.
70         13.000000  0.57
159         1.10                0.52            2.
29         11.750000  0.57
160         0.92                0.50            1.
04          7.650000  0.56
161         0.56                0.50            0.
80          5.880000  0.96
162         0.60                0.60            0.
96          5.580000  0.87
```

```
163         0.70                    0.40             0.
94          5.280000  0.68
164         0.68                    0.41             1.
03          9.580000  0.70
165         0.47                    0.52             1.
15          6.620000  0.78
166         0.92                    0.43             1.
46         10.680000  0.85
167         0.66                    0.40             0.
97         10.260000  0.72
168         0.84                    0.39             1.
54          8.660000  0.74
169         0.96                    0.27             1.
11          8.500000  0.67
170         0.49                    0.40             0.
73          5.500000  0.66
171         0.51                    0.48             0.
64          9.899999  0.57
172         0.70                    0.44             1.
24          9.700000  0.62
173         0.61                    0.52             1.
06          7.700000  0.64
174         0.75                    0.43             1.
41          7.300000  0.70
175         0.69                    0.43             1.
35         10.200000  0.59
176         0.68                    0.53             1.
46          9.300000  0.60
177         0.76                    0.56             1.
35          9.200000  0.61

     od280/od315_of_diluted_wines  proline
0                            3.92   1065.0
1                            3.40   1050.0
2                            3.17   1185.0
3                            3.45   1480.0
4                            2.93    735.0
5                            2.85   1450.0
6                            3.58   1290.0
7                            3.58   1295.0
8                            2.85   1045.0
9                            3.55   1045.0
10                           3.17   1510.0
11                           2.82   1280.0
12                           2.90   1320.0
```

13	2.73	1150.0
14	3.00	1547.0
15	2.88	1310.0
16	2.65	1280.0
17	2.57	1130.0
18	2.82	1680.0
19	3.36	845.0
20	3.71	780.0
21	3.52	770.0
22	4.00	1035.0
23	3.63	1015.0
24	3.82	845.0
25	3.20	830.0
26	3.22	1195.0
27	2.77	1285.0
28	3.40	915.0
29	3.59	1035.0
..	...	...
148	1.62	650.0
149	1.33	550.0
150	1.30	500.0
151	1.47	480.0
152	1.33	425.0
153	1.51	675.0
154	1.55	640.0
155	1.48	725.0
156	1.64	480.0
157	1.73	880.0
158	1.96	660.0
159	1.78	620.0
160	1.58	520.0
161	1.82	680.0
162	2.11	570.0
163	1.75	675.0
164	1.68	615.0
165	1.75	520.0
166	1.56	695.0
167	1.75	685.0
168	1.80	750.0
169	1.92	630.0
170	1.83	510.0
171	1.63	470.0
172	1.71	660.0
173	1.74	740.0
174	1.56	750.0

```
175                           1.56    835.0
176                           1.62    840.0
177                           1.60    560.0

[178 rows x 13 columns]
```

In [56]:

```
df = pd.DataFrame(wine.data,columns=wine.feature_names)
df['target'] = pd.Series(wine.target)
df.columns = ['Class label', 'Alcohol', 'Malic acid', 'Ash',
              'Alcalinity of ash', 'Magnesium', 'Total phenols',
              'Flavanoids', 'Nonflavanoid phenols', 'Proanthocya
nins',
              'Color intensity', 'Hue', 'OD280/OD315 of diluted
wines', 'Proline']
X = df.drop('Class label', 1)
y = df['Class label']
df.head()
print("The shape of features: ", df.shape)
print()
print(df.describe())
```

```
The shape of features:  (178, 14)

       Class label     Alcohol  Malic acid         A
sh  Alcalinity of ash  \
count   178.000000  178.000000  178.000000  178.0000
00         178.000000
mean     13.000618    2.336348    2.366517   19.4949
44          99.741573
std       0.811827    1.117146    0.274344    3.3395
64          14.282484
min      11.030000    0.740000    1.360000   10.6000
00          70.000000
25%      12.362500    1.602500    2.210000   17.2000
00          88.000000
50%      13.050000    1.865000    2.360000   19.5000
00          98.000000
75%      13.677500    3.082500    2.557500   21.5000
00         107.000000
max      14.830000    5.800000    3.230000   30.0000
00         162.000000

        Magnesium  Total phenols  Flavanoids  Nonfla
```

```
vanoid phenols  \
count  178.000000     178.000000  178.000000
178.000000
mean     2.295112       2.029270    0.361854
1.590899
std      0.625851       0.998859    0.124453
0.572359
min      0.980000       0.340000    0.130000
0.410000
25%      1.742500       1.205000    0.270000
1.250000
50%      2.355000       2.135000    0.340000
1.555000
75%      2.800000       2.875000    0.437500
1.950000
max      3.880000       5.080000    0.660000
3.580000

       Proanthocyanins  Color intensity         Hue
\
count       178.000000       178.000000  178.000000
mean          5.058090         0.957449    2.611685
std           2.318286         0.228572    0.709990
min           1.280000         0.480000    1.270000
25%           3.220000         0.782500    1.937500
50%           4.690000         0.965000    2.780000
75%           6.200000         1.120000    3.170000
max          13.000000         1.710000    4.000000

       OD280/OD315 of diluted wines     Proline
count                    178.000000  178.000000
mean                     746.893258    0.938202
std                      314.907474    0.775035
min                      278.000000    0.000000
25%                      500.500000    0.000000
50%                      673.500000    1.000000
75%                      985.000000    2.000000
max                     1680.000000    2.000000
```

In [60]:

```
#One-hot encode
df = pd.get_dummies(df)
df.iloc[:,5:].head(5)
```

Out[60]:

	Magnesium	Total phenols	Flavanoids	Nonflavanoid phenols	Proanthocyanin
0	2.80	3.06	0.28	2.29	5.64
1	2.65	2.76	0.26	1.28	4.38
2	2.80	3.24	0.30	2.81	5.68
3	3.85	3.49	0.24	2.18	7.80
4	2.80	2.69	0.39	1.82	4.32

In [88]:

```
#splitting dataset
X_train, X_test, y_train, y_test = train_test_split(wine.data, w
ine.target,
                                                    test_size =
.20,random_state = 42)
print("Split Shape")
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
print()
feature_list = list(df.columns)
```

```
Split Shape
(142, 13)
(36, 13)
(142,)
(36,)
```

In [79]:

```
#Linear Regression Model
print("==Linear Regression model accuracy scores==")
lm = LinearRegression()
model = lm.fit(X_train, y_train)
predictions = model.predict(X_test)
```

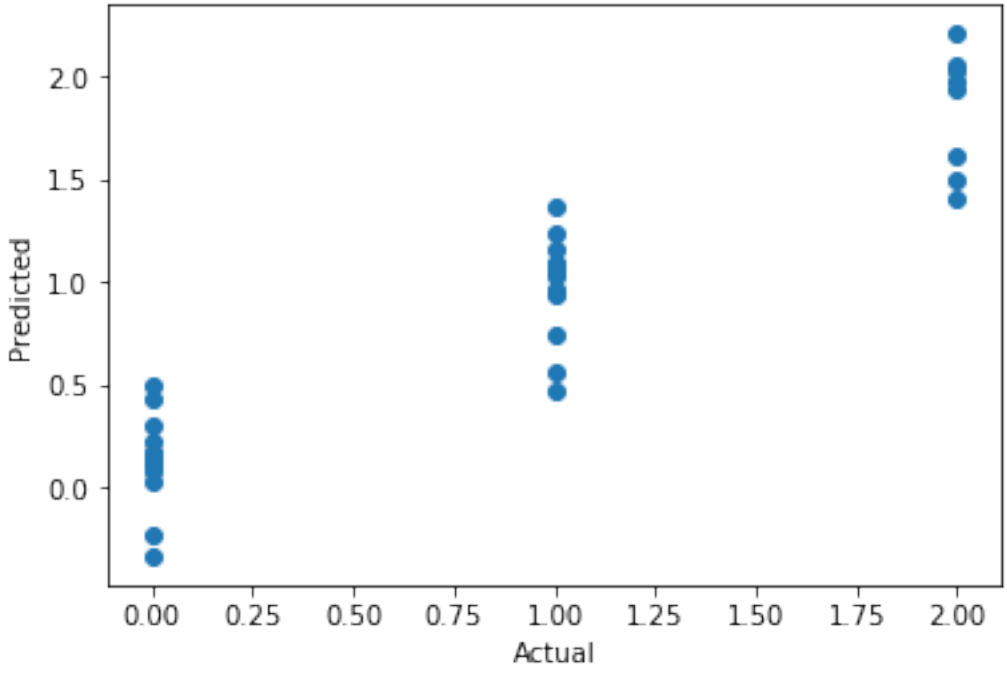
```
==Linear Regression model accuracy scores==
Accuracy on training set:0.903
Accuracy on test set:0.883
```

In [6]:

```
#Plotting Actual vs Predicted
plt.scatter(y_test, predictions)
plt.xlabel("Actual")
plt.ylabel("Predicted")
```

Out[6]:

```
Text(0,0.5,'Predicted')
```



In [91]:

```
#Linear Model training and testing stats
print('# of Training data points for (LM): %d' % X_train.shape[0
])
print('# of Testing data points for (LM): %d' % X_test.shape[0])
print()
print("Accuracy on training set (for LM): {:,.3f}".format(lm.sco
re(X_train, y_train)))
print("Accuracy on test set (for LM): {:,.3f}".format(lm.score(X
_test, y_test)))
print()
print('Class labels:', np.unique(wine.target))
print('Misclassified samples: %d' % (y_test != predictions).sum(
))
print()
errors = abs(predictions - y_test)
print("Mean absolute error:{:.3f}".format(np.mean(errors)))
```

```
# of Training data points for (LM): 142
# of Testing data points for (LM): 36

Accuracy on training set (for LM): 0.903
Accuracy on test set (for LM): 0.883

Class labels: [0 1 2]
Misclassified samples: 36

Mean absolute error:0.203
```

In [166]:

```
#Building Random Forest
forest = RandomForestClassifier(criterion='entropy',
                                n_estimators = 50,
                                min_samples_split = 20,
                                min_samples_leaf = 15,
                                max_features = 'sqrt',
                                max_leaf_nodes = 12,
                                random_state = 0)
forest.fit(X_train, y_train)
```

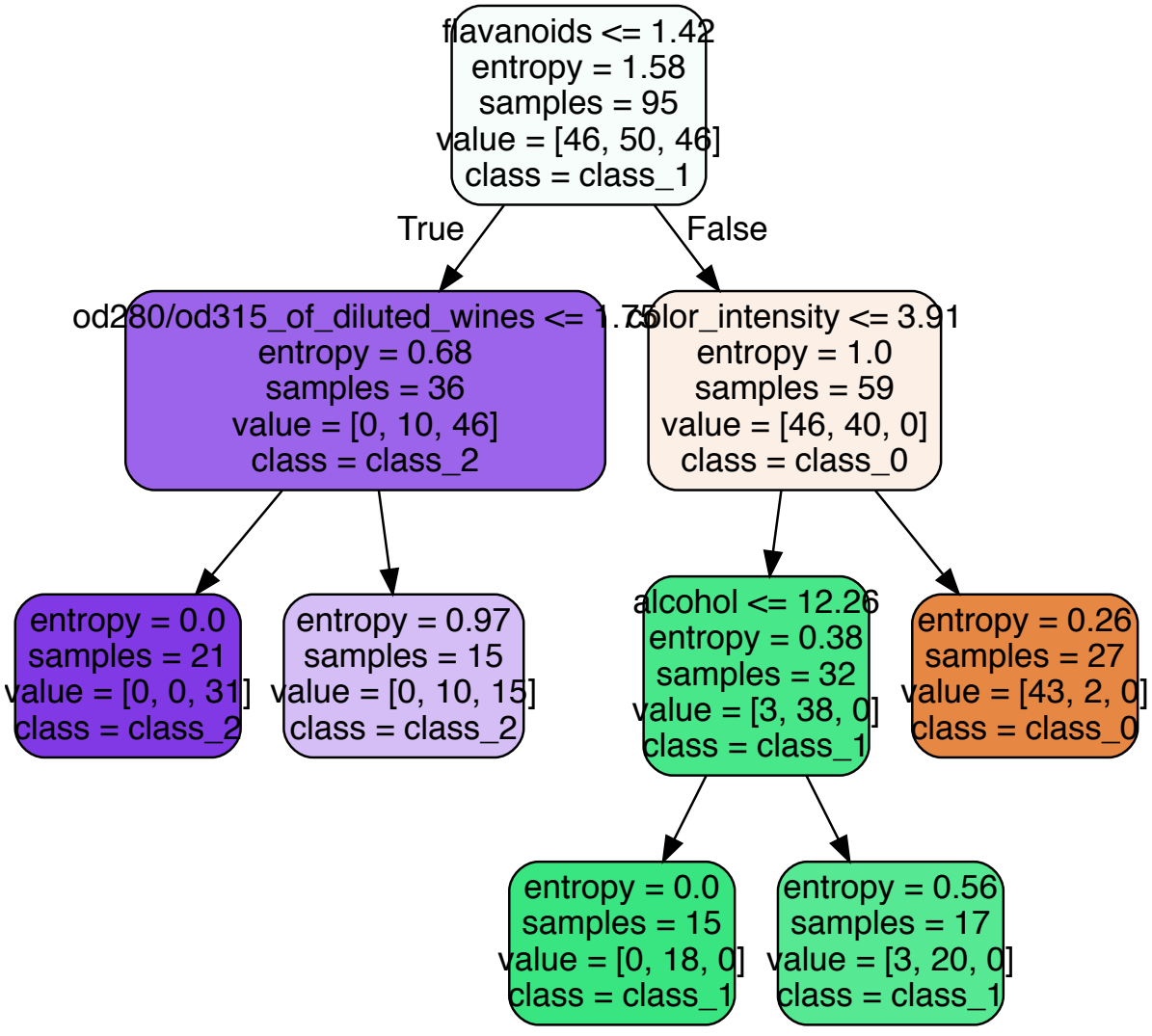
Out[166]:

```
RandomForestClassifier(bootstrap=True, class_weight=
None, criterion='entropy',
            max_depth=None, max_features='sqrt', max
_leaf_nodes=12,
            min_impurity_decrease=0.0, min_impurity_
split=None,
            min_samples_leaf=15, min_samples_split=2
0,
            min_weight_fraction_leaf=0.0, n_estimato
rs=50, n_jobs=1,
            oob_score=False, random_state=0, verbose
=0, warm_start=False)
```

In [167]:

```
#Display Random Forest
estimator = forest.estimators_[1]
export_graphviz(estimator, out_file = "rftree.dot",
                feature_names = wine.feature_names,
                class_names = wine.target_names,
                rounded = True, proportion = False,
                precision = 2, filled = True)


with open("rftree.dot") as f:
    dot_graph = f.read()
display(graphviz.Source(dot_graph))
```



In [114]:

```
#Random Forest results
print("Feature importance (Random Forest):\n{}".format(forest.fe
ature_importances_))
print()

y_pred = forest.predict(X_test)
print("Accuracy on training set (Random Forest): {:.3f}".format(
forest.score(X_train, y_train)))
print("Accuracy on test set (Random Forest): {:.3f}".format(fore
st.score(X_test, y_test)))
```

```
Feature importance (Random Forest):
[0.08645207 0.02298207 0.00459577 0.01097899 0.01080
313 0.07185554
 0.21358647 0.0217961  0.02726296 0.17818388 0.07486
819 0.16468787
 0.11194696]

Accuracy on training set (Random Forest): 0.986
Accuracy on test set (Random Forest): 0.917
```

In [138]:

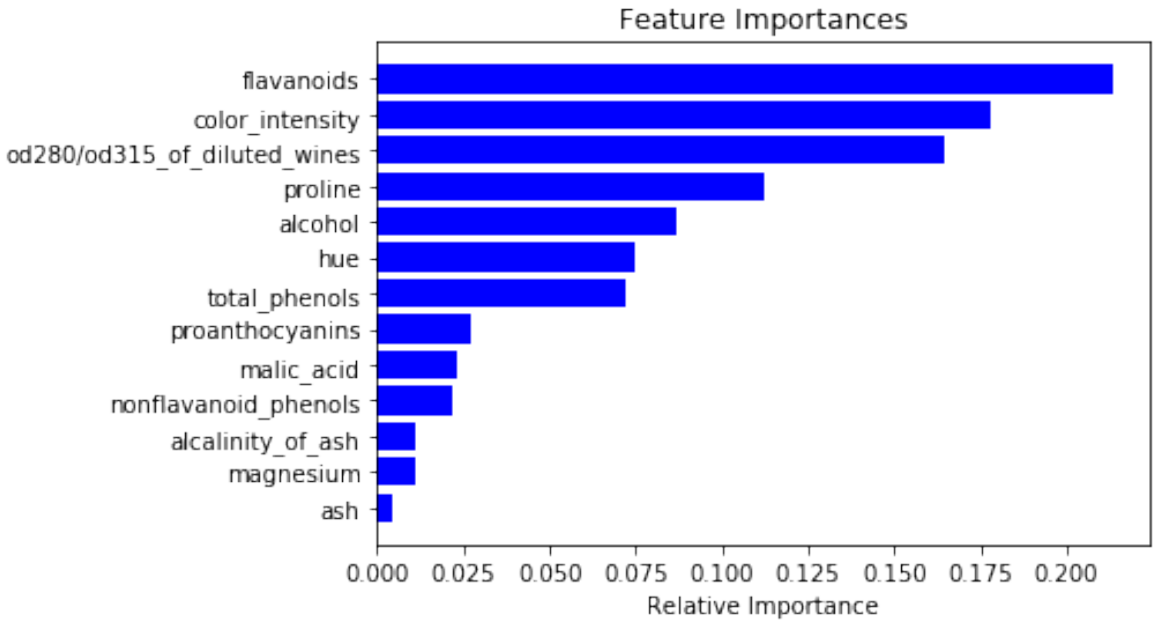
```
#Organizing feature importances for Random Forest
importances = forest.feature_importances_
#sorted indices
indices = np.argsort(importances)[::-1]

for f in range(X_train.shape[1]):
    print("%2d) %-*s %f" % (f + 1, 30,
                            X.columns.values[indices[f]],
                            importances[indices[f]]))
```

```
 1) Flavanoids                     0.213586
 2) Color intensity                0.178184
 3) OD280/OD315 of diluted wines   0.164688
 4) Proline                        0.111947
 5) Alcohol                        0.086452
 6) Hue                            0.074868
 7) Total phenols                  0.071856
 8) Proanthocyanins                0.027263
 9) Malic acid                     0.022982
10) Nonflavanoid phenols           0.021796
11) Alcalinity of ash              0.010979
12) Magnesium                      0.010803
13) Ash                            0.004596
```

In [139]:

```
print()
features = wine['feature_names']
indices = np.argsort(importances)
plt.title('Feature Importances')
plt.barh(range(len(indices)), importances[indices], color='b', a
lign='center')
plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



In [169]:

```
cumulative_importances = np.cumsum(importances)
print('Number of features for 95% importance:', np.where(cumulat
ive_importances > 0.95)[0][0]+1)
#Cross Validation
X_train, X_test, y_train, y_test = train_test_split(wine.data, w
ine.target, test_size = .20, random_state = 0)
forest_cv_score = cross_val_score(forest, wine.data, wine.target
, cv=10)
```

```
Number of features for 95% importance: 13
```

In [189]:

```
rf = RandomForestClassifier()
pp.pprint(rf.get_params())
print()

n_estimators = [int(x) for x in np.linspace(start = 200, stop =
2000, num = 10)]
max_features = ['auto', 'sqrt']
max_depth = [int(x) for x in np.linspace(10, 110, num = 11)]
max_depth.append(None)
min_samples_split = [2, 5, 10]
min_samples_leaf = [1, 2, 4]
bootstrap = [True, False]# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
pp.pprint(random_grid)
print()

rf_random = RandomizedSearchCV(estimator = rf,
                        param_distributions = random_grid,
                        n_iter = 10,
                        cv = 3,
                        verbose = 2,
                        random_state = 42,
                        n_jobs = -1)
rf_random.fit(X_train, y_train)
```

```
{   'bootstrap': True,
    'class_weight': None,
    'criterion': 'gini',
    'max_depth': None,
    'max_features': 'auto',
    'max_leaf_nodes': None,
    'min_impurity_decrease': 0.0,
    'min_impurity_split': None,
    'min_samples_leaf': 1,
    'min_samples_split': 2,
    'min_weight_fraction_leaf': 0.0,
    'n_estimators': 10,
```

```
    'n_jobs': 1,
    'oob_score': False,
    'random_state': None,
    'verbose': 0,
    'warm_start': False}

{   'bootstrap': [True, False],
    'max_depth': [10, 20, 30, 40, 50, 60, 70, 80, 90
, 100, 110, None],
    'max_features': ['auto', 'sqrt'],
    'min_samples_leaf': [1, 2, 4],
    'min_samples_split': [2, 5, 10],
    'n_estimators': [200, 400, 600, 800, 1000, 1200,
1400, 1600, 1800, 2000]}

Fitting 3 folds for each of 10 candidates, totalling
30 fits
[CV] n_estimators=200, min_samples_split=10, min_sam
ples_leaf=2, max_features=sqrt, max_depth=50, bootst
rap=True
[CV] n_estimators=200, min_samples_split=10, min_sam
ples_leaf=2, max_features=sqrt, max_depth=50, bootst
rap=True
[CV] n_estimators=200, min_samples_split=10, min_sam
ples_leaf=2, max_features=sqrt, max_depth=50, bootst
rap=True
[CV] n_estimators=600, min_samples_split=10, min_sam
ples_leaf=4, max_features=sqrt, max_depth=90, bootst
rap=False
[CV]  n_estimators=200, min_samples_split=10, min_sa
mples_leaf=2, max_features=sqrt, max_depth=50, boots
trap=True, total=   0.6s
[CV] n_estimators=600, min_samples_split=10, min_sam
ples_leaf=4, max_features=sqrt, max_depth=90, bootst
rap=False
[CV]  n_estimators=200, min_samples_split=10, min_sa
mples_leaf=2, max_features=sqrt, max_depth=50, boots
trap=True, total=   0.6s
[CV]  n_estimators=200, min_samples_split=10, min_sa
mples_leaf=2, max_features=sqrt, max_depth=50, boots
trap=True, total=   0.6s
[CV] n_estimators=600, min_samples_split=10, min_sam
ples_leaf=4, max_features=sqrt, max_depth=90, bootst
rap=False
[CV] n_estimators=600, min_samples_split=2, min_samp
```

```
les_leaf=2, max_features=auto, max_depth=60, bootstr
ap=False
[CV]  n_estimators=600, min_samples_split=10, min_sa
mples_leaf=4, max_features=sqrt, max_depth=90, boots
trap=False, total=   1.9s
[CV] n_estimators=600, min_samples_split=2, min_samp
les_leaf=2, max_features=auto, max_depth=60, bootstr
ap=False
[CV]  n_estimators=600, min_samples_split=10, min_sa
mples_leaf=4, max_features=sqrt, max_depth=90, boots
trap=False, total=   1.8s
[CV] n_estimators=600, min_samples_split=2, min_samp
les_leaf=2, max_features=auto, max_depth=60, bootstr
ap=False
[CV]  n_estimators=600, min_samples_split=10, min_sa
mples_leaf=4, max_features=sqrt, max_depth=90, boots
trap=False, total=   1.9s
[CV] n_estimators=1400, min_samples_split=5, min_sam
ples_leaf=1, max_features=sqrt, max_depth=30, bootst
rap=True
[CV]  n_estimators=600, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=60, bootst
rap=False, total=   1.8s
[CV] n_estimators=1400, min_samples_split=5, min_sam
ples_leaf=1, max_features=sqrt, max_depth=30, bootst
rap=True
[CV]  n_estimators=600, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=60, bootst
rap=False, total=   1.9s
[CV] n_estimators=1400, min_samples_split=5, min_sam
ples_leaf=1, max_features=sqrt, max_depth=30, bootst
rap=True
[CV]  n_estimators=600, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=60, bootst
rap=False, total=   1.8s
[CV] n_estimators=1000, min_samples_split=10, min_sa
mples_leaf=1, max_features=auto, max_depth=80, boots
trap=False
[CV]  n_estimators=1400, min_samples_split=5, min_sa
mples_leaf=1, max_features=sqrt, max_depth=30, boots
trap=True, total=   3.9s
[CV] n_estimators=1000, min_samples_split=10, min_sa
mples_leaf=1, max_features=auto, max_depth=80, boots
trap=False
[CV]  n_estimators=1400, min_samples_split=5, min_sa
```

```
mples_leaf=1, max_features=sqrt, max_depth=30, boots
trap=True, total=   3.9s
[CV] n_estimators=1000, min_samples_split=10, min_sa
mples_leaf=1, max_features=auto, max_depth=80, boots
trap=False
[CV]  n_estimators=1000, min_samples_split=10, min_s
amples_leaf=1, max_features=auto, max_depth=80, boot
strap=False, total=   2.6s
[CV] n_estimators=400, min_samples_split=10, min_sam
ples_leaf=1, max_features=sqrt, max_depth=60, bootst
rap=False
[CV]  n_estimators=1400, min_samples_split=5, min_sa
mples_leaf=1, max_features=sqrt, max_depth=30, boots
trap=True, total=   3.8s
[CV] n_estimators=400, min_samples_split=10, min_sam
ples_leaf=1, max_features=sqrt, max_depth=60, bootst
rap=False
[CV]  n_estimators=400, min_samples_split=10, min_sa
mples_leaf=1, max_features=sqrt, max_depth=60, boots
trap=False, total=   1.2s
[CV] n_estimators=400, min_samples_split=10, min_sam
ples_leaf=1, max_features=sqrt, max_depth=60, bootst
rap=False
[CV]  n_estimators=400, min_samples_split=10, min_sa
mples_leaf=1, max_features=sqrt, max_depth=60, boots
trap=False, total=   1.1s
[CV] n_estimators=2000, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=False
[CV]  n_estimators=400, min_samples_split=10, min_sa
mples_leaf=1, max_features=sqrt, max_depth=60, boots
trap=False, total=   1.0s
[CV] n_estimators=2000, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=False
[CV]  n_estimators=1000, min_samples_split=10, min_s
amples_leaf=1, max_features=auto, max_depth=80, boot
strap=False, total=   2.8s
[CV] n_estimators=2000, min_samples_split=2, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=False
[CV]  n_estimators=1000, min_samples_split=10, min_s
amples_leaf=1, max_features=auto, max_depth=80, boot
strap=False, total=   2.8s
[CV] n_estimators=200, min_samples_split=5, min_samp
```

```
les_leaf=2, max_features=sqrt, max_depth=10, bootstr
ap=True
[CV]  n_estimators=200, min_samples_split=5, min_sam
ples_leaf=2, max_features=sqrt, max_depth=10, bootst
rap=True, total=   0.5s
[CV] n_estimators=200, min_samples_split=5, min_samp
les_leaf=2, max_features=sqrt, max_depth=10, bootstr
ap=True
[CV]  n_estimators=200, min_samples_split=5, min_sam
ples_leaf=2, max_features=sqrt, max_depth=10, bootst
rap=True, total=   0.6s
[CV] n_estimators=200, min_samples_split=5, min_samp
les_leaf=2, max_features=sqrt, max_depth=10, bootstr
ap=True
[CV]  n_estimators=200, min_samples_split=5, min_sam
ples_leaf=2, max_features=sqrt, max_depth=10, bootst
rap=True, total=   0.6s
[CV] n_estimators=1200, min_samples_split=2, min_sam
ples_leaf=4, max_features=auto, max_depth=100, boots
trap=True
[CV]  n_estimators=2000, min_samples_split=2, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=False, total=   5.8s
[CV] n_estimators=1200, min_samples_split=2, min_sam
ples_leaf=4, max_features=auto, max_depth=100, boots
trap=True
[CV]  n_estimators=1200, min_samples_split=2, min_sa
mples_leaf=4, max_features=auto, max_depth=100, boot
strap=True, total=   3.6s
[CV] n_estimators=1200, min_samples_split=2, min_sam
ples_leaf=4, max_features=auto, max_depth=100, boots
trap=True
[CV]  n_estimators=2000, min_samples_split=2, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=False, total=   5.8s
[CV] n_estimators=2000, min_samples_split=5, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=True
[CV]  n_estimators=2000, min_samples_split=2, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=False, total=   5.9s
[CV] n_estimators=2000, min_samples_split=5, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=True
[CV]  n_estimators=1200, min_samples_split=2, min_sa
```

```
mples_leaf=4, max_features=auto, max_depth=100, boot
strap=True, total=   3.4s
[CV] n_estimators=2000, min_samples_split=5, min_sam
ples_leaf=2, max_features=auto, max_depth=50, bootst
rap=True
[CV]  n_estimators=1200, min_samples_split=2, min_sa
mples_leaf=4, max_features=auto, max_depth=100, boot
strap=True, total=   3.4s
[CV]  n_estimators=2000, min_samples_split=5, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=True, total=   5.2s
[CV]  n_estimators=2000, min_samples_split=5, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=True, total=   5.1s
[CV]  n_estimators=2000, min_samples_split=5, min_sa
mples_leaf=2, max_features=auto, max_depth=50, boots
trap=True, total=   3.6s

[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed
:   22.6s finished
```

Out[189]:

```
RandomizedSearchCV(cv=3, error_score='raise',
          estimator=RandomForestClassifier(bootstrap
=True, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max
_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_
split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimato
rs=10, n_jobs=1,
            oob_score=False, random_state=None, verb
ose=0,
            warm_start=False),
          fit_params=None, iid=True, n_iter=10, n_jo
bs=-1,
          param_distributions={'n_estimators': [200,
400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000],
'max_features': ['auto', 'sqrt'], 'max_depth': [10,
20, 30, 40, 50, 60, 70, 80, 90, 100, 110, None], 'mi
n_samples_split': [2, 5, 10], 'min_samples_leaf': [1
, 2, 4], 'bootstrap': [True, False]},
          pre_dispatch='2*n_jobs', random_state=42,
refit=True,
          return_train_score='warn', scoring=None, v
erbose=2)
```

In [190]:

```
rf_random.best_params_
```

Out[190]:

```
{'bootstrap': True,
 'max_depth': 10,
 'max_features': 'sqrt',
 'min_samples_leaf': 2,
 'min_samples_split': 5,
 'n_estimators': 200}
```

In [191]:

```
predictions = rf_random.predict(X_test)
print("Accuracy on training set (RF2): {:,.3f}".format(rf_random
.score(X_train, y_train)))
print("Accuracy on test set (RF2): {:,.3f}".format(rf_random.sco
re(X_test, y_test)))
print()
print('Class labels:', np.unique(wine.target))
print('Misclassified samples: %d' % (y_test != predictions).sum(
))
print()
errors = abs(predictions - y_test)
print("Mean absolute error:{:.3f}".format(np.mean(errors)))
```

```
Accuracy on training set (for LM): 1.000
Accuracy on test set (for LM): 0.933

Class labels: [0 1 2]
Misclassified samples: 3

Mean absolute error:0.067
```

In [195]:

```
#Create grid based on random search
param_grid = {
'bootstrap': [True],
'max_depth': [80, 90, 100, 110],
'max_features': [2, 3],
'min_samples_leaf': [3, 4, 5],
'min_samples_split': [8, 10, 12],
'n_estimators': [100, 200, 300, 1000]
}

rf = RandomForestClassifier()
grid_search = GridSearchCV(estimator = rf,
                           param_grid = param_grid,
                          cv = 3, n_jobs = -1, verbose = 2)
grid_search.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 288 candidates, totallin
g 864 fits
[CV] bootstrap=True, max_depth=80, max_features=2, m
```

```
in_samples_leaf=3, min_samples_split=8, n_estimators
=100
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=100
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=100
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.3s
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=200
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.7s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
```

```
in_samples_leaf=3, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.9s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   1.0s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=200
```

```
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   3.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   3.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   3.1s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
```

```
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=100
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
```

```
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
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rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=4, min_samples_split=8, n_estimators
=100

[Parallel(n_jobs=-1)]: Done  33 tasks      | elapsed
:    9.1s

[CV]  bootstrap=True, max_depth=80, max_features=2,
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=100
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min_samples_leaf=4, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
```

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in_samples_leaf=4, min_samples_split=8, n_estimators
=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100, total=   0.2s
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=200
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min_samples_leaf=4, min_samples_split=8, n_estimator
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=300
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.4s
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in_samples_leaf=4, min_samples_split=8, n_estimators
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=4, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=2,
```

```
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=4, min_samples_split=8, n_estimators
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=1000
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s=300, total=   0.7s
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s=100
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rs=200, total=   0.6s
```

```
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s=200
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s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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s=300
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s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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s=1000, total=   2.7s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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in_samples_leaf=4, min_samples_split=12, n_estimator
s=100
```

```
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```

```
rs=200, total=   0.5s
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s=100, total=   0.2s
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in_samples_leaf=5, min_samples_split=8, n_estimators
```

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=200
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s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=5, min_samples_split=12, n_estimator
s=100
```

```
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=5, min_samples_split=12, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=2, m
in_samples_leaf=5, min_samples_split=12, n_estimator
s=200
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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rs=200, total=   0.5s
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s=200
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.4s
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s=300
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rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=2, m
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s=300
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rs=200, total=   0.5s
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in_samples_leaf=5, min_samples_split=12, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=2,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
```

```
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in_samples_leaf=5, min_samples_split=12, n_estimator
s=1000
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min_samples_leaf=5, min_samples_split=12, n_estimato
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s=1000
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rs=300, total=   0.7s
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rs=300, total=   0.7s
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s=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=8, n_estimators
```

```
=200
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s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
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```

```
s=300, total=   0.8s
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s=100
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rs=100, total=   0.2s
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s=100
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=100
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rs=100, total=   0.3s
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s=200
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min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   2.4s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=3,
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
```

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in_samples_leaf=3, min_samples_split=10, n_estimator
s=300
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rs=200, total=   0.5s
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s=1000, total=   2.5s
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s=1000
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min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=10, n_estimator
s=1000
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rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=3,
```

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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=200
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=200
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
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rs=1000, total=   2.7s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
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rs=1000, total=   2.5s
[CV]  bootstrap=True, max_depth=80, max_features=3,
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=300
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
```

```
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
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rs=300, total=   0.7s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=1000
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rs=300, total=   0.7s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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=100
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[CV] bootstrap=True, max_depth=80, max_features=3, m
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[CV] bootstrap=True, max_depth=80, max_features=3, m
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rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=8, n_estimators
=200
```

```
[CV]  bootstrap=True, max_depth=80, max_features=3,
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s=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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=300
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s=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=8, n_estimators
=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=8, n_estimators
=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
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s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
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s=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
```

```
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=100

[Parallel(n_jobs=-1)]: Done 154 tasks      | elapsed
:   41.8s

[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=100
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=200
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min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=200
[CV]  bootstrap=True, max_depth=80, max_features=3,
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s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.4s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
```

```
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=300
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=10, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=80, max_features=3, m
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s=1000
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min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=80, max_features=3, m
```

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s=200
[CV]  bootstrap=True, max_depth=80, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=80, max_features=3, m
in_samples_leaf=4, min_samples_split=12, n_estimator
s=200
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min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
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rs=300, total=   0.8s
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rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=90, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=300
[CV] bootstrap=True, max_depth=90, max_features=2, m
in_samples_leaf=3, min_samples_split=12, n_estimator
s=300
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
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in_samples_leaf=3, min_samples_split=12, n_estimator
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min_samples_leaf=3, min_samples_split=10, n_estimato
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=100
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rs=300, total=   0.8s
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min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=90, max_features=2, m
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s=100
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rs=100, total=   0.3s
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s=300
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min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=90, max_features=2, m
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=200
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=200
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[CV] bootstrap=True, max_depth=90, max_features=3, m
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rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=90, max_features=3, m
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=100

[Parallel(n_jobs=-1)]: Done 357 tasks      | elapsed
:  1.6min

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min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.3s
[CV] bootstrap=True, max_depth=90, max_features=3, m
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=100
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=200
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rs=1000, total=   2.7s
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in_samples_leaf=5, min_samples_split=8, n_estimators
=200
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s=200, total=   0.5s
[CV] bootstrap=True, max_depth=90, max_features=3, m
in_samples_leaf=5, min_samples_split=8, n_estimators
=300
[CV]  bootstrap=True, max_depth=90, max_features=3,
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rs=1000, total=   2.6s
```

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=300
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rs=1000, total=   2.6s
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=300
[CV]  bootstrap=True, max_depth=90, max_features=3,
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[CV] bootstrap=True, max_depth=90, max_features=3, m
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s=100
```

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[CV]  bootstrap=True, max_depth=90, max_features=3,
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rs=300, total=   0.8s
```

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s=300
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s=100
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[CV] bootstrap=True, max_depth=100, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=100, max_features=2,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.6s
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s=200
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s=300
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rs=1000, total=   2.6s
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s=300
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s=200, total=   0.5s
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s=300, total=   0.8s
```

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s=1000
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min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.8s
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s=1000
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rs=200
```

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rs=100
[CV]  bootstrap=True, max_depth=100, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.2s
```

```
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rs=100
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rs=200, total=   0.5s
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rs=300
```

```
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s=200, total=   0.5s
```

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s=1000
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s=300
[CV]  bootstrap=True, max_depth=100, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300
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min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.6s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000
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min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100, total=   0.2s
```

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rs=100
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min_samples_leaf=3, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=200
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min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
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s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
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s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300
```

```
[CV]  bootstrap=True, max_depth=100, max_features=3,
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[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=300, total=   0.8s
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rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
```

```
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=200
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rs=1000, total=   2.6s
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rs=300
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rs=1000
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rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=1000
```

```
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s=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
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s=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
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s=300
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rs=1000, total=   2.5s
```

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s=300
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rs=100
```

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rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=300, total=   0.8s
```

```
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rs=200
```

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s=100
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s=100, total=   0.3s
```

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s=100, total=   0.3s
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s=100
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s=300
```

```
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[CV]  bootstrap=True, max_depth=100, max_features=3,
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s=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300, total=   0.9s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200, total=   0.5s
```

```
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300
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s=1000, total=   2.7s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
```

```
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
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rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
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rs=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
```

```
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300

[Parallel(n_jobs=-1)]: Done 640 tasks      | elapsed
:  2.9min

[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
```

```
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=200
[CV]  bootstrap=True, max_depth=100, max_features=3,
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rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=300
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rs=1000, total=   2.5s
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s=300
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s=300
[CV]  bootstrap=True, max_depth=100, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
```

```
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
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s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=1000
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rs=100
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rs=100, total=   0.3s
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rs=100
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rs=100, total=   0.3s
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rs=100
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rs=100, total=   0.3s
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rs=200
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=3, min_samples_split=10, n_estimato
```

```
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=200
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rs=300
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rs=300
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rs=200, total=   0.5s
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rs=1000
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rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
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```

```
rs=100
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rs=100, total=   0.2s
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rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=200, total=   0.5s
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rs=200
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rs=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
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```

```
rs=200, total=   0.5s
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rs=300
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rs=1000, total=   2.5s
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rs=1000
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rs=1000
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min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
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s=100
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min_samples_leaf=4, min_samples_split=8, n_estimator
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s=100
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[CV]  bootstrap=True, max_depth=110, max_features=2,
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s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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```

```
s=200
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s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
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s=200, total=   0.5s
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rs=1000, total=   2.5s
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s=1000
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s=300, total=   0.8s
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```

```
s=300, total=   0.8s
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
```

```
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
```

```
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.4s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=300
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min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.4s
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rs=300
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min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
```

```
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.7s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000
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min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=8, n_estimator
```

```
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=200
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=1000, total=   2.5s
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s=300
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=1000, total=   2.4s
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s=300
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s=200, total=   0.5s
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s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=2,
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s=1000
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s=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
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s=300, total=   0.8s
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```

```
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=100, total=   0.2s
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rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
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rs=300
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rs=300
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```

```
rs=200, total=   0.5s
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rs=300
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rs=100
[CV]  bootstrap=True, max_depth=110, max_features=2,
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rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
```

```
rs=200
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rs=300, total=   0.8s
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rs=1000
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```

```
rs=300, total=   0.8s
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rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=2,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.3s
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s=100
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min_samples_leaf=3, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
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s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
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```

```
s=300
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s=300, total=   0.8s
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rs=100
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```

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rs=100, total=   0.2s
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rs=100
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rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
```

```
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.4s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
```

```
rs=200, total=   0.5s
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=10, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
```

```
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
```

```
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=3, min_samples_split=12, n_estimato
rs=1000, total=   2.4s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
```

```
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
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s=1000, total=   2.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
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rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=8, n_estimator
s=1000, total=   2.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
```

```
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200
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min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.7s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
```

```
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.7s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=10, n_estimato
rs=1000, total=   2.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
```

```
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=4, min_samples_split=12, n_estimato
rs=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
```

```
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
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rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
```

```
rs=200, total=   0.5s
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000, total=   2.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=200
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
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rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
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rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=8, n_estimator
s=1000, total=   2.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=300, total=   0.9s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
```

```
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.3s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=100, total=   0.2s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=200, total=   0.5s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.7s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
```

```
rs=200, total=   0.6s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=10, n_estimato
rs=1000, total=   2.7s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV] bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=300, total=   0.8s
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000, total=   2.0s
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000, total=   2.0s
[CV]  bootstrap=True, max_depth=110, max_features=3,
min_samples_leaf=5, min_samples_split=12, n_estimato
rs=1000, total=   2.0s

[Parallel(n_jobs=-1)]: Done 864 out of 864 | elapsed
:  4.0min finished
```

Out[195]:

```
GridSearchCV(cv=3, error_score='raise',
       estimator=RandomForestClassifier(bootstrap=Tr
ue, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max
_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_
split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimato
rs=10, n_jobs=1,
            oob_score=False, random_state=None, verb
ose=0,
            warm_start=False),
       fit_params=None, iid=True, n_jobs=-1,
       param_grid={'bootstrap': [True], 'max_depth':
[80, 90, 100, 110], 'max_features': [2, 3], 'min_sam
ples_leaf': [3, 4, 5], 'min_samples_split': [8, 10,
12], 'n_estimators': [100, 200, 300, 1000]},
       pre_dispatch='2*n_jobs', refit=True, return_t
rain_score='warn',
       scoring=None, verbose=2)
```

In [196]:

```
grid_search.best_params_
```

Out[196]:

```
{'bootstrap': True,
 'max_depth': 100,
 'max_features': 2,
 'min_samples_leaf': 3,
 'min_samples_split': 8,
 'n_estimators': 100}
```

In [148]:

```
print("=====CONFUSION MATRIX=====")
print(confusion_matrix(y_test, forest.predict(X_test)))
print('\n')

print("=====CLASSIFICATION REPORT=====")
print(classification_report(y_test, forest.predict(X_test)))
print('\n')

print("AUC SCORES")
print(forest_cv_score)
print('\n')
print("MEAN AUC SCORES")
print("Mean AUC Score - Random Forest: ", forest_cv_score.mean()
)
```

```
=====CONFUSION MATRIX=====
[[14  0  0]
 [ 2 13  1]
 [ 0  0  6]]


=====CLASSIFICATION REPORT=====
             precision    recall  f1-score   support

          0       0.88      1.00      0.93        14
          1       1.00      0.81      0.90        16
          2       0.86      1.00      0.92         6

avg / total       0.93      0.92      0.92        36



AUC SCORES
[0.89473684 0.88888889 1.         0.94444444 0.94444
444 1.
 1.         1.         0.94117647 1.        ]


MEAN AUC SCORES
Mean AUC Score - Random Forest:  0.9613691090471276
```

In [ ]:

```
#
```

In [199]:

```
#
```

In [201]:

```
#grid_search= GridSearchCV(SVC(), grid, cv = 10, return_train_sc
ore = True)
#print(grid_search)
```

In [202]:

```
scores = cross_val_score(logreg, wine.data, wine.target)
print("Cross-validation scores:{}".format(scores))
print()
scores = cross_val_score(logreg, wine.data, wine.target, cv = 5)
print("Cross-validation scores:{}".format(scores))
print()
print("Average cross-validation score:{:.2f}".format(scores.mean
()))
```

```
Cross-validation scores:[0.86666667 0.95       1.
]

Cross-validation scores:[0.91891892 0.94444444 0.944
44444 1.         1.        ]

Average cross-validation score:0.96
```

In [203]:

```
kfold = KFold(n_splits = 5)
scores = cross_val_score(logreg, wine.data, wine.target, cv = kf
old)
print()
print("Cross-validation scores:\n{}".format(scores))
kfold = KFold(n_splits = 3)
scores = cross_val_score(logreg, wine.data, wine.target, cv = kf
old)
print()
print("Cross-validation scores:\n{}".format(scores))
kfold = KFold(n_splits=3, shuffle=True, random_state=0)
scores = cross_val_score(logreg, wine.data, wine.target, cv=kfol
d)
print()
print("Cross-validation scores: \n{}".format(scores))
```

```
Cross-validation scores:
[0.91666667 0.91666667 0.88888889 0.94285714 1.
]

Cross-validation scores:
[0.01666667 0.69491525 0.18644068]

Cross-validation scores:
[0.95       0.91525424 0.96610169]
```

In [204]:

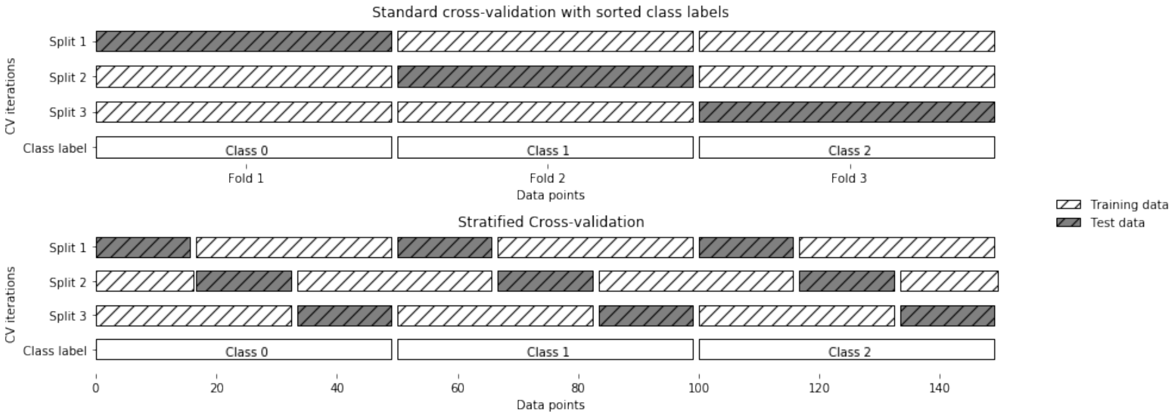
```
loo = LeaveOneOut()
scores = cross_val_score(logreg, wine.data, wine.target, cv=loo)
print("Number of cv iterations: ", len(scores))
print("Mean accuracy: {:.2f}".format(scores.mean()))
```

```
Number of cv iterations:  178
Mean accuracy: 0.96
```

In [205]:

```
print("Wine labels:\n{}".format(wine.target))
mglearn.plots.plot_stratified_cross_validation()
```

```
Wine labels:
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2]
```



In [207]:

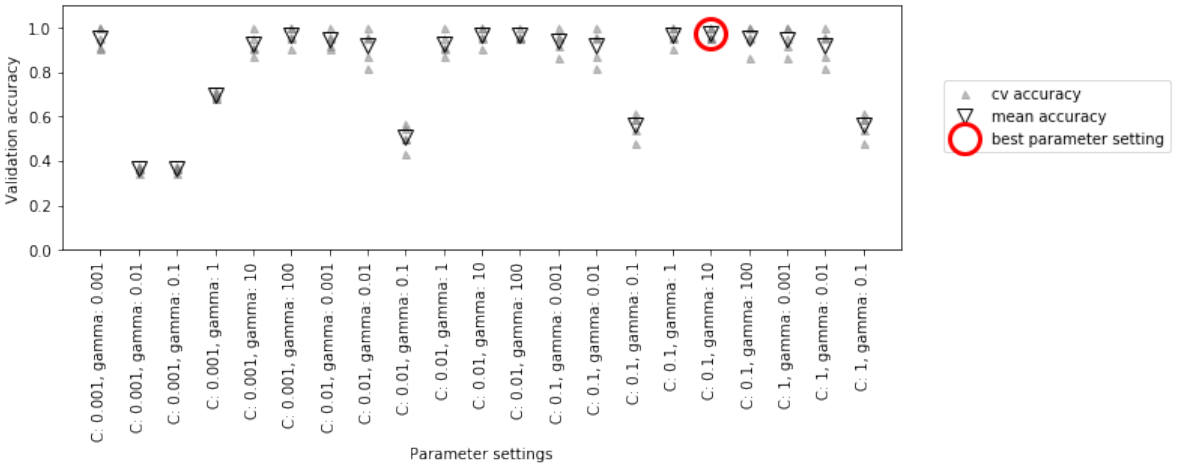
```
#split data into train & validation & test
X_trainval, X_test, y_trainval, y_test = train_test_split(wine.d
ata, wine.target,
                                                    random_state
=0)

#split train & validation into train & validation
X_train, X_valid, y_train, y_valid = train_test_split(X_trainval
, y_trainval,
                                                    random_state
=1)

print("Size of training set: {}  size of validation set: {}
size of tets set:"
      "{}\n".format(X_train.shape[0], X_valid.shape[0], X_test.s
hape[0]))
best_score=0
for gamma in [0.001, 0.01, 0.1, 1, 10, 100]:
    for C in [0.001, 0.01, 0.1, 1, 10, 100]:
        #for each combination of parameters, train an SVC
        svm = SVC(gamma=gamma, C=C)
        #perform cross-validation
        scores = cross_val_score(svm, X_trainval, y_trainval, cv
=5)
        #compute mean cross-validation accuracy
        score = np.mean(scores)
        # if get better score, store score and parameters
        if score > best_score:
            best_score = score
            best_parameters = {'C':C, 'gamma':gamma}

# rebuild a model on the combined training and validation set,
# and evalaute it on the test set
svm = SVC(**best_parameters)
svm.fit(X_trainval, y_trainval)
mglearn.plots.plot_cross_val_selection()
```

```
Size of training set: 99  size of validation set: 34
size of tets set:45
```



In [209]:

```
rf=RandomForestClassifier()
rf.fit(X_train, y_train)
rf.fit(X_test, y_test)
rf.fit(X_trainval, y_trainval)
```

Out[209]:

```
RandomForestClassifier(bootstrap=True, class_weight=
None, criterion='gini',
            max_depth=None, max_features='auto', max
_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_
split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimato
rs=10, n_jobs=1,
            oob_score=False, random_state=None, verb
ose=0,
            warm_start=False)
```

In [212]:

```
print("Accuracy on training set (Final RF): {:,.3f}".format(rf.s
core(X_train, y_train)))
print("Accuracy on training set (Final RF): {:,.3f}".format(rf.s
core(X_trainval, y_trainval)))
print("Accuracy on test set (Final RF): {:,.3f}".format(rf.score
(X_test, y_test)))
```

```
Accuracy on training set (Final RF): 1.000
Accuracy on training set (Final RF): 1.000
Accuracy on test set (Final RF): 0.978
```